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AIR QUALITY MONITORING REPORT FOR ALBERTA

1989

Technical Report Series

Alberta
ENVIRONMENT

AIR QUALITY MONITORING REPORT
FOR ALBERTA
1989

Technical Report Series No. 92-1a

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Environmental Assessment Division
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Air Quality Monitoring Report for Alberta: 1989 - Technical Report Series No. 92-1a.
Air Quality Monitoring Data Summary for Alberta: 1989 - Technical Report Series No. 92-1b.

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SUMMARY

Alberta Environment has conducted air quality monitoring in the province since the early 1960s. The objectives of the monitoring program are to: (1) report existing air quality; (2) determine trends of air quality; (3) inform the public of adverse air quality conditions; and (4) conduct monitoring in special problem areas. In 1989, the air quality monitoring program consisted of continuous, intermittent, static, portable, mobile and acid precipitation monitoring networks. Air quality monitoring data from continuous, intermittent, static and acid precipitation networks are summarized below. The regulations and guidelines for individual pollutants are discussed in detail in the main text of this report. Data from portable and mobile monitoring networks are available from independent Alberta Environment reports.

Continuous Air Quality Monitoring

Continuous air quality monitoring is the measurement of pollutant concentrations on an 1-hour average basis. Pollutants that are monitored continuously by Alberta Environment include ammonia, carbon monoxide, the coefficient of haze (dust and smoke), hydrogen sulphide, oxides of nitrogen (including nitrogen oxide and nitrogen dioxide), ozone, sulphur dioxide and total hydrocarbons. Continuous monitoring stations are located in downtown, residential and industrial areas of Edmonton and Calgary as well as at Fort Saskatchewan, Fort McMurray and Fort MacKay.

The Index of the Quality of the Air

The Index of the Quality of the Air (IQUA), which was developed by a federal-provincial committee in 1978, is a way of indicating air quality in simple and concise terms. The IQUA relates concentrations of five major continuously monitored pollutants (sulphur dioxide, carbon monoxide, ozone, nitrogen dioxide and coefficient of haze) to a common scale which may be easily interpreted by the public. This scale associates Good, Fair, Poor and Very Poor air quality categories to federal and provincial air quality objectives. The IQUA is reported twice daily (8:15 a.m. and 3:15 p.m.) at Edmonton and Calgary.

The IQUA was in the Good category the majority of the time at all stations. The frequency of good air quality ratings ranged from 83% at the Calgary industrial monitoring station to 98% at the Fort Saskatchewan monitoring station. Fair and Poor air quality categories were most frequent at the Calgary industrial monitoring location. The IQUA was in the Very Poor category for three hours at the Calgary industrial monitoring location in 1989. The majority of Poor and Very Poor air quality readings at all stations were due to the coefficient of haze (i.e., dust and smoke in the atmosphere).

Ammonia

Ammonia is a colourless gas with a pungent odour. Ammonia is emitted into the atmosphere through natural sources such as animal decay and animal excretions, and man-made sources such as the fertilizer industry.

Ambient ammonia concentrations recorded at Fort Saskatchewan were below the detectable limit of 0.1 ppm 95% of the time. The peak ammonia concentration was 0.6 ppm (parts per million). Maximum ammonia concentrations at Fort Saskatchewan were well below the Alberta Environment guideline of 2.0 ppm.

Carbon Monoxide

Carbon monoxide is a colourless, odourless gas emitted into the atmosphere primarily by motor vehicles in urban areas. Minor sources of carbon monoxide include fireplaces, industry, aircraft and natural gas combustion.

Exceedances of the 1-hour and 8-hour regulations for carbon monoxide were recorded at the Edmonton downtown and residential monitoring stations and at all the Calgary monitoring stations. The highest percentage of exceedances was recorded at the downtown locations of Edmonton and Calgary as well as the Calgary industrial monitoring location. Carbon monoxide shows a downward trend at all of these stations based on 14 years of data.

The Coefficient of Haze

The coefficient of haze is an indicator of dust and smoke in the atmosphere which interferes with visibility. Dust and smoke may originate from road dust, wind-blown soil, industrial sources, automobile emissions, agricultural activities and various other sources.

The guideline for the coefficient of haze was exceeded only at the Calgary industrial monitoring location in January and November. The coefficient of haze shows an upward trend at the Edmonton industrial monitoring location.

Hydrogen Sulphide

Hydrogen sulphide is a colourless gas with a rotten egg odour. Industrial sources include petroleum refineries, natural gas plants, petrochemical plants, coke oven plants, pulp and paper plants which use the kraft pulping process. Significant quantities of hydrogen sulphide are also emitted from natural sources such as sloughs and swamps.

Exceedances of the 1-hour and 24-hour regulations for hydrogen sulphide were recorded at the Calgary industrial monitoring location. These exceedances were likely caused by fugitive emissions of hydrogen sulphide from industrial facilities in the vicinity. Exceedances of the regulations were not recorded at any other stations that monitor for hydrogen sulphide.

Nitrogen Dioxide

Nitrogen dioxide is a reddish-brown gas with a pungent odour. Sources of nitrogen dioxide in Alberta include the oil and gas industry, transportation (vehicle and aircraft emissions), power plants, natural gas and heating fuel combustion, and forest fires. The largest urban source of nitrogen dioxide is vehicular emissions.

The regulation for annual-average nitrogen dioxide concentrations was only exceeded at the Calgary downtown monitoring location in 1989. The 1-hour, 24-hour and annual-average regulations were not exceeded at any other stations. A downward trend in nitrogen dioxide at the Edmonton downtown monitoring location is noted.

Ozone

At ambient atmospheric concentrations, ozone is a colourless, odourless gas. Ozone is generated in the atmosphere through a photochemical reaction between sunlight, nitrogen dioxide and hydrocarbons. Ozone may also be transported down to ground-level from the upper atmosphere. The build-up of ozone precursors such as oxides of nitrogen and hydrocarbons during the winter may contribute to high spring time ozone concentrations.

The 1-hour regulation for ozone was exceeded four times at the Calgary residential monitoring station and one time at the Fort Saskatchewan monitoring station. The 24-hour regulation was exceeded at all monitoring stations. The frequency of exceedances ranged from 46 days at the Calgary and Edmonton downtown monitoring locations to 153 days at the Calgary residential monitoring location. An upward trend in ozone concentration is evident from data collected at the Calgary downtown monitoring station.

Sulphur Dioxide

Sulphur dioxide is a colourless gas with a pungent odour. The most common sources of sulphur dioxide in Alberta are natural gas extraction plants, oil sands plants, coal-fired power plants, oil refineries, pulp and paper mills, fertilizer plants and diesel-powered transport vehicles.

Exceedances of the 1-hour regulation for sulphur dioxide were recorded for a total of seven hours at the Fort MacKay monitoring station in 1989. The source of the exceedances was likely oil sands processing facilities in the region. Exceedances of the regulations for sulphur dioxide were not recorded at any other Alberta Environment monitoring stations.

Total Hydrocarbons

The term "total hydrocarbons" refers to non-reactive and reactive hydrocarbons. Non-reactive hydrocarbons, such as methane, occur naturally in the atmosphere. Reactive hydrocarbons (or volatile organic compounds) exist in the atmosphere primarily through man-made emissions. Reactive hydrocarbons may react with sunlight to form ozone. Sources of reactive hydrocarbons include vegetation, vehicular emissions, petroleum storage tanks and other industrial sources.

A maximum total hydrocarbon concentration of 16.0 ppm was recorded at the Edmonton industrial monitoring location. Sources of hydrocarbons in the Edmonton industrial area were likely petroleum storage tanks, refineries, vehicular emissions, painting and drycleaning. No regulations exist for ambient total hydrocarbon concentrations.

Intermittent Air Quality Monitoring

Suspended particulates were monitored at all Edmonton and Calgary continuous monitoring stations as well as at Ellerslie (15 km south-southwest of downtown Edmonton) and Fort Saskatchewan. Suspended particulates are monitored every sixth day in accordance with the National Air Pollution Surveillance (NAPS) system as a 24-hour accumulated loading. Chemical analysis is conducted on suspended particulate samples to quantify loadings of total suspended particulates, Benzo (a) Pyrene and lead. Vinyl chloride monomers were monitored, on an intermittent basis, at three locations in the Fort Saskatchewan area.

Total Suspended Particulates

Suspended particulates are particles which range from about 0.001 to 500 microns in diameter (a human hair is about 100 microns in diameter) and, depending on their density, may remain suspended in the air for an indefinite period of time. Suspended particulates may originate from soil, road and agricultural dust; smoke from forest fires and recreational fires; vehicular exhaust emissions; and industrial sources.

The 24-hour regulation for total suspended particulates was exceeded at all Edmonton, Calgary and Fort Saskatchewan monitoring stations. The greatest frequency of exceedances was observed at the Edmonton downtown, Calgary downtown and Calgary industrial monitoring locations. Total suspended particulate loadings show a downward trend, based on 10 years of data, at the Edmonton residential monitoring station and all Calgary monitoring stations.

Benzo (a) Pyrene

Benzo (a) Pyrene is a polycyclic aromatic hydrocarbon (PAH) that is contained in all types of soot and smoke. Vehicular exhaust, and smoke from industrial and recreational emissions are the most common sources of Benzo (a) Pyrene.

Benzo (a) Pyrene loadings were substantially greater at Edmonton downtown, Edmonton residential, Calgary downtown and Calgary industrial monitoring locations than at the more rural monitoring locations. These stations are all located relatively close to major traffic arteries. The major source of Benzo (a) Pyrene at these stations is vehicular emissions. Based on eight years of data, Benzo (a) Pyrene loadings show a significant increase at both Edmonton and Calgary residential monitoring stations. This is most likely due to increased traffic density in these regions.

Lead

Lead is emitted into the atmosphere primarily as a result of burning leaded gasoline in motor vehicles. Other sources of atmospheric lead include iron and steel manufacturing, solid waste incineration and battery manufacturing.

As would be expected, lead loadings are much higher at locations in close proximity to major traffic arteries than in rural locations. The highest annual average lead loadings were recorded at Edmonton downtown and residential, and Calgary downtown and industrial monitoring locations. A maximum annual average lead loading of 0.25 ug/m^3 (micrograms per cubic meter) was recorded at the Calgary industrial monitoring station. A trend toward lower lead loadings is obvious at all Edmonton, Calgary and Fort Saskatchewan monitoring stations. This trend is a reflection of the decrease in the use of leaded gasoline over the past decade. Alberta Environment does not have regulations or guidelines for ambient loadings of lead.

Vinyl Chloride Monomer

When present in the atmosphere, vinyl chloride monomer is a colourless gas with a faint sweet odour. Vinyl chloride monomer is emitted into the atmosphere during the manufacturing of clothing, building and construction materials, home furnishings, and packaging for toys and plastics.

Average vinyl chloride monomer concentrations from August to December ranged from 0.16 ppb (parts per billion) at the Fort Saskatchewan monitoring unit to 0.17 ppb at the monitoring location in the vicinity of the Diamond Shamrock plant (now known as the BF Goodrich processing plant) to 0.23 ppb in the vicinity of the Dow Chemical plant. Alberta Environment does not have regulations for atmospheric concentrations of vinyl chloride monomer.

Static Air Quality Monitoring

Alberta Environment conducts air quality monitoring, on a static basis, at approximately 70 networks throughout Alberta. Static monitoring is the measurement of total accumulated loadings of pollutants on a one- and three-month schedule. Parameters monitored on a static basis include total dustfall, calcium, total sulphation, hydrogen sulphide and fluorides.

Total Dustfall

Dustfall is defined as the fraction of particulate that does not remain suspended in the atmosphere for an indefinite period of time. Sources of dustfall include wind-blown soil, road dust, dust generated by agricultural activities, ash from forest fires and recreational fires, and flyash from industrial sources.

Total dustfall loadings exceeded Alberta Environment guidelines for residential regions at all 13 networks where total dustfall is monitored. Guidelines for industrial regions were exceeded less than 15% of the time at eight of these networks. The major sources of dustfall in Alberta include road dust, agricultural dust, dust from industrial sources and vehicular exhaust.

Calcium

Calcium emanates from natural sources such as wind-blown soil and road dust. Man-made sources of calcium in dustfall include cement, iron, steel and wood processing.

The highest annual average calcium loading recorded in 1989 was 13.5 mg/100 sq cm/30 days (milligrams per 100 square centimeters per 30 days) which was measured at the Exshaw network. This value is over 2.5 times the calcium loadings recorded in the Edmonton area. This relatively high value may be attributed to cement manufacturing activities in the Exshaw vicinity.

Total Sulphation

Total sulphation is the measurement of all sulphur-containing compounds which exist in the atmosphere. Sulphur recovery gas plants, coal-burning power plants and petroleum are common sources of total sulphation.

Total sulphation was monitored at 19 networks, on a one-month basis and 34 networks on a three-month basis in Alberta during 1989. The guideline for total sulphation was exceeded only at the Redwater network on one occasion in 1989. The highest annual-average total sulphation value was also recorded at the Redwater network.

Hydrogen Sulphide

Hydrogen sulphide is present in the atmosphere from natural sources such as coal, natural gas, oil, sulphur hot springs, sloughs, swamps and lakes. Industrial sources of hydrogen sulphide include petroleum refining plants, natural gas plants, petrochemical complexes, coke oven plants, pulp and paper plants employing the kraft pulping process, and petroleum and gas gathering fields.

A total of 10 networks monitor hydrogen sulphide on a monthly basis while 35 networks monitor hydrogen sulphide on a three-month basis. Exceedances of the guideline for hydrogen sulphide did not occur at any static monitoring networks in 1989. The highest annual-average hydrogen sulphide loading was observed at the Fort McMurray network.

Fluorides

Fluorides are emitted into the atmosphere through processes such as coal combustion and the processing of phosphate bearing rock. Alberta Environment operates four fluoride monitoring networks in the province.

Fluoride loadings were the highest at the Calgary monitoring network in 1989 with an annual-average loading of 36 ug/100 sq cm/30 days (micrograms per 100 square centimeters per 30 days). Approximately 20% of the data collected from the Calgary network exceeded the guideline for fluorides of 40 ug/100 sq cm/30 days.

Acid Precipitation Monitoring

Precipitation chemistry was monitored, as an accumulation over a one-month period, at 13 locations in the province by Alberta Environment in 1989. The purpose of the network is to monitor the quality of precipitation, detect significant trends of precipitation quality and observe long-range transport of pollutants into the province. Chemical analysis was conducted on precipitation samples to obtain pH, major cations (calcium, ammonium, sodium, magnesium and potassium) and major anions (sulphate, nitrate, chloride and phosphate).

pH

Based on analysis of precipitation samples collected in 1989, the most acidic precipitation (lowest pH) was deposited in the Fort McMurray region (pH 4.7). The least acidic precipitation (highest pH) occurred in the Suffield (pH 6.0) and Whitecourt (pH 5.9) regions. On an annual average basis, nearly normal precipitation pH was observed at High Prairie, Cold Lake, Edmonton, Fort Vermilion and Red Deer. The pH of uncontaminated precipitation in 5.6.

Anions (sulphate, nitrate, chloride, phosphate)

Anions are negatively charged ions contained within precipitation which result from acids when parent species react with water vapour. The parent species may be emitted into the atmosphere from coal-fired power plants, oil refineries, gas plants, oil sands plants, pulp and paper plants, fertilizer plants, vehicular emissions and agricultural activities.

Wet sulphate and nitrate deposition rates reached a maximum at Calgary (7.8 kg/ha/yr (kilograms per hectare per year) and 6.1 kg/ha/yr, respectively) and Cold Lake (7.2 kg/ha/yr and 5.8 kg/ha/yr, respectively) in 1989. Maximum chloride wet deposition rates were also observed at Calgary. Wet phosphate deposition was relatively low at all monitoring stations.

Cations (calcium, ammonium, sodium, magnesium, potassium)

Cations are positively charged ions which are formed when parent species go into solution. Cations may originate from industrial sources such as iron, steel and wood manufacturing, or natural sources such as wind-blown soil and dust.

Wet calcium deposition was a maximum at High Prairie (2.0 kg/ha/yr) and Calgary (2.5 kg/ha/yr). Maximum wet ammonium deposition occurred at Cold Lake and Edmonton where values of 2.2 and 2.1 kg/ha/yr were recorded. Wet sodium and magnesium deposition rates were highest at Calgary (1.2 and 0.5 kg/ha/yr, respectively) while wet potassium deposition reached at maximum at High Prairie (1.8 kg/ha/yr).

ACKNOWLEDGEMENTS

The report that follows is a summary of air quality activities that were conducted by Alberta Environment in the province of Alberta during 1989. A great deal of technical expertise is necessary to collect high quality data from such an extensive monitoring program. The dedicated individuals who established and maintained this comprehensive monitoring program are accredited with this accomplishment.

J. Torneby, D. Kupina, D. Bensler, J. Ross, E. Boyko and T. Spackman established and maintained the continuous, intermittent and static monitoring networks. J. Godin was responsible for the operation of the acid precipitation monitoring network. Special acknowledgement is given to R. Brassard and his staff for the continual mechanical upkeep of ambient monitoring equipment. The Alberta Environmental Centre in Vegreville analyzed samples from the intermittent, static and acid precipitation monitoring networks.

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LIST OF ABBREVIATIONS

IQUA - Index of the Quality of the Air
NH_3 - ammonia
CO - carbon monoxide
COH - coefficient of haze
H_2S - hydrogen sulphide
NO_2 - nitrogen dioxide
NO - nitric oxide
NO_x - oxides of nitrogen
N_2O - nitrous oxide
O_3 - ozone
SO_2 - sulphur dioxide
THC - total hydrocarbons
TSP - total suspended particulates
BaP - Benzo (a) Pyrene
Pb - lead
VCM - vinyl chloride monomer
$SO_4^=$ - sulphate ion
NO_3^- - nitrate ion
NH_4^+ - ammonium ion
Cl^- - chloride ion
$PO_4^=$ - phosphate ion
Na^+ - sodium ion
K^+ - potassium ion
Ca^{++} - calcium ion
Mg^{++} - magnesium ion
ppm - parts per million by volume
ppb - parts per billion by volume
ug/m^3 - micrograms per cubic meter
$ug/1000\ m^3$ - micrograms per 1000 cubic meters
kg/ha/yr - kilograms per hectare per year
NAPS - National Air Pollution Surveillance

mg/100 sq cm/30 days - milligrams per 100 square centimeters per 30 days
ug/100 sq cm/30 days - micrograms per 100 square centimeters per 30 days
mg SO_3 equivalent/day/100 sq cm - milligrams expressed as sulphite per day per 100 square centimeters

1. INTRODUCTION

Air quality is an issue which has received increased attention over the past decade. Alberta Environment recognizes that the quality of the environment is affected by the quality of the air, water and soil. The Environmental Quality Monitoring Branch of Alberta Environment has the responsibility of monitoring and reporting ambient air quality. When applicable, air quality is compared to established regulations and guidelines.

The Environmental Quality Monitoring Branch operates a comprehensive air quality monitoring program consisting of continuous, intermittent, static, mobile, portable and acid precipitation monitoring networks. The objectives of this air quality monitoring program are to:

- provide data for the assessment of existing air quality relative to regulations and objectives;
- report long-term trends in air quality;
- inform the public on the status of air quality; and
- undertake monitoring in special problem areas.

This report documents and analyzes air quality data for 1989 from January 1 to December 31. When exceedances of the regulations or guidelines occur, an attempt is made to relate the exceedances to wind direction so that the source or sources of the pollutant may be identified. Long-term trends of pollutant concentrations are also presented and an explanation of these trends is included.

Air quality instrumentation and data are subject to a stringent quality control and quality assurance program. Instrument calibration and data collection procedures are detailed in the Alberta Environment Air Monitoring Directive (Alberta Environment 1989). After the data has been collected, monthly quality control is conducted by a technologist to ensure that the data presented in monthly and annual reports is certified as being correct. If the quality of the data is questionable, it is deleted from monthly and annual reports.

Detailed analyses of data collected by continuous, intermittent, static and acid precipitation monitoring networks that are operated by Alberta Environment are presented in this report. Information collected by portable and mobile monitoring programs are summarized in this report. The data used to generate this report are detailed in a separate document entitled "Air Quality Monitoring Data Summary for Alberta: 1989".

2. AIR QUALITY MONITORING NETWORKS

2.1 CONTINUOUS MONITORING NETWORK

Air pollutants are monitored on a continuous basis at nine locations in Alberta. Three continuous monitoring stations are located in each of Calgary and Edmonton. Additional stations are located in Fort Saskatchewan, Fort McMurray and Fort MacKay. Each continuous monitoring unit is equipped to monitor various air quality and meteorological parameters on an hourly basis. These parameters are listed in Table 2.1. The locations of continuous monitoring stations are presented in Figure 2-1 and Table 2.2.

The Edmonton and Calgary stations are designated according to the general location of the stations in the downtown, residential and industrial areas of the city. All Edmonton and Calgary air quality stations are equipped to monitor ambient concentrations of carbon monoxide (CO), oxides of nitrogen (including NO and NO_2), ozone (O_3), total hydrocarbons (THC) and coefficient of haze (COH). In addition, the Edmonton industrial monitoring unit monitors sulphur dioxide (SO_2) and the Calgary industrial monitoring unit monitors sulphur dioxide and hydrogen sulphide (H_2S). With the exception of the Edmonton and Calgary downtown locations, all stations monitor wind speed and direction.

The continuous monitoring unit located in Fort Saskatchewan monitors for the same pollutants as the Calgary industrial monitoring station (i.e., CO, NO_x, NO, NO_2, O_3, THC, COH, SO_2 and H_2S) with the addition of ammonia (NH_3). The Fort Saskatchewan monitoring unit was closed temporarily from November 1988 to May 1989 due to construction near the site. The station was moved from downtown to a location on the old Fort Saskatchewan jail site during this time period. Data collection at the new location began on June 1, 1989.

The Fort McMurray monitoring station measures the same pollutants as the Calgary industrial monitoring unit. Only SO_2, H_2S and THC are monitored at the Fort MacKay monitoring station.

Table 2.1 Pollutants monitored continuously at Alberta Environment monitoring stations.

Monitoring Station	Parameter								
	NH_3	CO	COH	H_2S	NO_x[a]	O_3	SO_2	THC	Wind
Edmonton Downtown		X	X		X	X		X	
Edmonton Residential		X	X		X	X		X	X
Edmonton Industrial		X	X		X	X	X	X	X
Calgary Downtown		X	X		X	X		X	
Calgary Residential		X	X		X	X		X	X
Calgary Industrial		X	X	X	X	X	X	X	X
Fort Saskatchewan	X	X	X	X	X	X	X	X	X
Fort McMurray		X	X	X	X	X	X	X	X
Fort MacKay				X			X	X	X

[a] includes NO_2 and NO

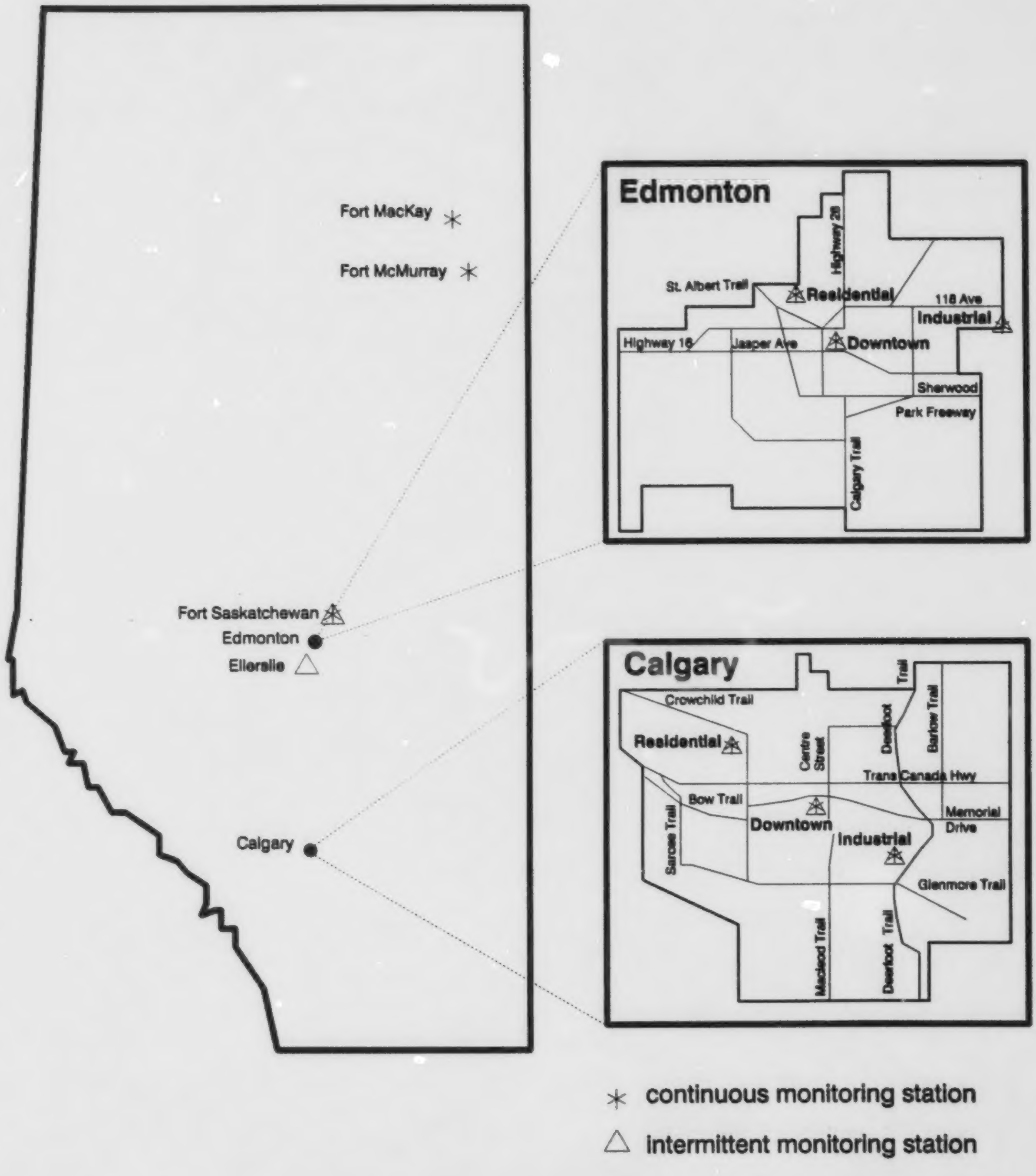
Fort MacKay
Fort McMurray
Fort Saskatchewan
Edmonton
Ellerslie
Calgary
Edmonton
Highway 28
St. Albert Trail
Residential
118 Ave
Industrial
Highway 16
Jasper Ave
Downtown
Sherwood
Park Freeway
Calgary Trail
Calgary
Crowchild Trail
Trail
Residential
Centre Street
Deerfoot
Barlow Trail
Trans Canada Hwy
Bow Trail
Sarcee Trail
Downtown
Industrial
Memorial Drive
Glenmore Trail
Macleod Trail
Deerfoot Trail
✳ continuous monitoring station
△ intermittent monitoring station

Figure 2-1 Location of continuous and intermittent air quality monitoring stations.

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Table 2.2 Location of continuous monitoring stations.

Station Name	Station Location
Edmonton Downtown Monitoring Unit (EDMU)	10255 - 104 St.
Edmonton Residential Monitoring Unit (ERMU)	13335 - 127 St.
Edmonton Industrial Monitoring Unit (EIMU)	105 Ave. and 17 St.
Calgary Downtown Monitoring Unit (CDMU)	611 - 4 St. S.W.
Calgary Residential Monitoring Unit (CRMU)	39 St. and 29 Ave. N.W.
Calgary Industrial Monitoring Unit (CIMU)	49 Ave. and 15 St. S.E.
Fort Saskatchewan Monitoring Unit (EMMU)	100 Ave. and 98 St.
Fort McMurray Monitoring Unit (FMMU)	Franklin Ave. at old waterpump house site
Fort MacKay Monitoring Unit (FRMU)	100 m west of the Fort MacKay Band Council Administration Office

2.2 INTERMITTENT MONITORING NETWORK

Suspended particulates are monitored, as a 24-hour accumulated loading, at each of the Edmonton and Calgary continuous monitoring locations as well as at Fort Saskatchewan and Ellerslie (refer to Figure 2-1). Suspended particulate samples are collected by high-volume samplers and subsequently submitted for laboratory analysis to quantify loadings of total suspended particulates (TSP), lead (Pb) and Benzo (a) Pyrene (BaP). Suspended particulates are monitored on every sixth day according to the National Air Pollution Surveillance (NAPS) schedule.

In addition to suspended particulates monitored by high-volume samplers, Alberta Environment also operates two dichotomous samplers and one selective size inlet (SSI) sampler in the province. The dichotomous samplers are located at the Edmonton and Calgary downtown continuous monitoring locations while the SSI sampler is situated at the Edmonton downtown continuous monitoring station. The dichotomous sampler seperates particulates into two size fractions; fine (less than 2.5 microns in diameter) and coarse

(2.5 to 10 microns in diameter) (a human hair is about 100 microns in diameter). The SSI sampler monitors all particulates with a diameter less than 10 microns. The monitoring frequency of the dichotomous and SSI instruments conforms to the NAPS network schedule (i.e., every sixth day). These monitoring programs are conducted in cooperation with Environment Canada.

In 1989, vinyl chloride monomer (VCM) was monitored at three sites in the Fort Saskatchewan region because of the town's proximity to chemical processing plants. These sites are located at the Fort Saskatchewan continuous monitoring location, west of the Diamond Shamrock petrochemical processing plant (now known as the BF Goodrich petrochemical processing plant) and west of the Dow Chemical petrochemical processing plant.

2.3 STATIC MONITORING NETWORK

Static monitoring is the measurement of total accumulations of pollutant loadings over a specified time period. This time period is either one-month or three-months in duration. Total sulphation, hydrogen sulphide, total dustfall, fluorides and calcium are monitored on a static basis. Approximately 70 static monitoring networks are administered by Alberta Environment in the province. Figure 2-2 shows static monitoring network locations. Network locations and number of monitoring stations per network are indicated in Tables 2.3 to 2.7.

2.4 PORTABLE MONITORING PROGRAMS

Portable monitoring programs are air monitoring projects that are initiated on the basis of public complaints, requests by municipal officials or for special projects. In 1989, portable monitoring programs were conducted in Lethbridge, Drayton Valley and the Fort Saskatchewan region.

A portable monitoring station was located at 905 - 4 Ave. South in Lethbridge from October 1 to December 31, 1989. The purpose of this study was to determine general air quality over a three-month period in the City of Lethbridge. The parameters monitored

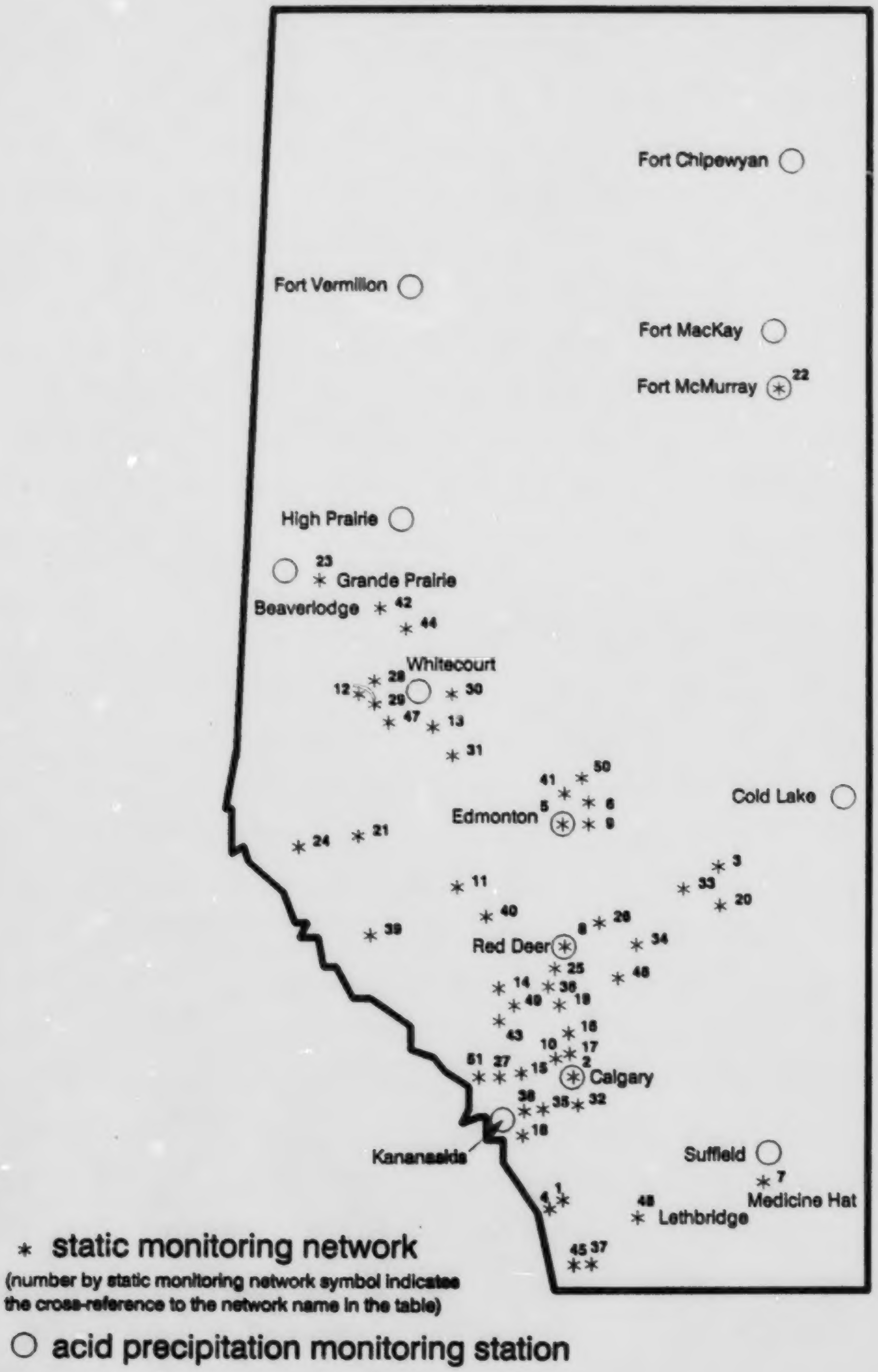
Fort Chipewyan
Fort Vermilion
Fort MacKay
Fort McMurray
22
High Prairie
23
Grande Prairie
Beaverlodge
42
44
Whitecourt
12
28
29
30
47
13
31
41
50
5
6
9
Edmonton
Cold Lake
24
21
3
33
20
11
40
26
8
39
34
Red Deer
25
14
36
46
49
19
43
16
10
17
51
27
15
2
Calgary
38
35
32
18
Kananaskis
Suffield
7
Medicine Hat
4
1
48
Lethbridge
45
37
* static monitoring network
(number by static monitoring network symbol indicates the cross-reference to the network name in the table)
○ acid precipitation monitoring station

Figure 2-2 Location of static monitoring networks and acid precipitation monitoring stations.

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Table 2.3 Location of networks where total dustfall is monitored on a static basis.

Network Location	# of Stations	Monitoring Period	Map Location
Blairmore	2	1 month	1
Calgary	6	1 month	2
Camrose	1	1 month	3
Coleman	12	1 month	4
Edmonton	27	1 month	5
Edmonton Industrial	1	1 month	5
Edmonton Residential	1	1 month	5
Exshaw	5	1 month	51
Fort Saskatchewan (special)	1	1 month	6
Medicine Hat	5	1 month	7
Red Deer	1	1 month	8
Sarcee (Calgary)	8	1 month	2
Sherwood Park	3	1 month	9

Table 2.4 Location of networks where calcium is monitored on a static basis.

Network Location	# of Stations	Monitoring Period	Map Location
Edmonton	3	1 month	5
Edmonton Industrial	1	1 month	5
Edmonton Residential	1	1 month	5
Exshaw	5	1 month	51

Table 2.5 Location of networks where hydrogen sulphide is monitored on a static basis.

Network Location	# of Stations	Monitoring Period	Map Location
Balzac	4	3 months	10
Buck Lake	4	3 months	11
Bigstone	2	3 months	12
Blue Ridge	4	3 months	13
Caroline	2	3 months	14
Cochrane	4	3 months	15
Coleman	4	3 months	4
Camrose	1	1 month	3
Carstairs	4	3 months	16
Crossfield	5	3 months	17
Diamond Valley	4	3 months	18
Didsbury	8	3 months	19
Edburg	1	3 months	20
Edson	4	3 months	21
Fort Saskatchewan (special)	1	1 month	6
Fort McMurray	6	1 month	22
Grande Prairie	1	1 month	23
Hinton	3	1 month	24
Innisfail	4	3 months	25
Joffre	2	1 month	26
Jumping Pound	4	3 months	27
Kaybob	4	3 months	28
Kaybob (south)	4	3 months	29
Lone Pine Creek	5	3 months	30
Mayerthorpe	2	3 months	31
Mazeppa	4	3 months	32
New Norway	1	1 month	33

Table 2.5 (cont.) **Location of networks where hydrogen sulphide is monitored on a static basis.**

Network Location	# of Stations	Monitoring Period	Map Location
Nevis	7	3 months	34
Okotoks	5	3 months	35
Olds	4	3 months	36
Pincher Creek	6	3 months	37
Quirk Creek	6	3 months	38
Ram River	5	3 months	39
Red Deer (city)	2	1 month	8
Red Deer	4	3 months	8
Redwater	4	3 months	50
Rimbey	4	3 months	40
Sherwood Park	3	1 month	9
St. Albert	2	1 month	41
Simonette	2	3 months	42
Sundre	2	3 months	43
Valleyview	2	3 months	44
Waterton	8	3 months	45
Wimborne	4	3 months	46
Windfall	4	3 months	47

Table 2.6 **Location of networks where total sulphation is monitored on a static basis.**

Network Location	# of Stations	Monitoring Period	Map Location
Balzac	4	3 months	10
Buck Lake	4	3 months	11
Bigstone	2	3 months	12
Blue Ridge	4	3 months	13
Calgary	38	1 month	2
Caroline	2	3 months	14
Cochrane	4	3 months	15
Coleman	4	3 months	4
Camrose	1	1 month	3
Carstairs	4	3 months	16
Crossfield	5	3 months	17
Diamond Valley	4	3 months	18
Didsbury	8	3 months	19
Edburg	1	3 months	20
Edmonton	27	1 month	5
Edmonton Industrial	1	1 month	5
Edmonton Residential	1	1 month	5
Edson	4	3 months	21
Fort McMurray	6	1 month	22
Fort Saskatchewan	4	1 month	6
Fort Saskatchewan (special)	1	1 month	6
Grande Prairie	1	1 month	23
Hinton	3	1 month	24
Innisfail	4	3 months	25
Joffre	2	1 month	26
Jumping Pound	4	3 months	27
Kaybob	4	3 months	28

Table 2.6 (cont.) Location of networks where total sulphation is monitored on a static basis.

Network Location	# of Stations	Monitoring Period	Map Location
Kaybob (south)	4	3 months	29
Lethbridge	5	1 month	48
Lone Pine Creek	5	3 months	30
Mayerthorpe	2	3 months	31
Mazeppa	4	3 months	32
Medicine Hat	5	1 month	7
New Norway	1	1 month	33
Nevis	7	3 months	34
Okotoks	5	3 months	35
Olds	4	3 months	36
Pincher Creek	6	3 months	37
Quirk Creek	6	3 months	38
Ram River	5	3 months	39
Raven Brood	1	1 month	49
Red Deer (city)	2	1 month	8
Red Deer	4	3 months	8
Redwater	4	3 months	50
Redwater	4	1 month	50
Rimbey	4	3 months	40
Sherwood Park	3	1 month	9
St. Albert	2	1 month	41
Simonette	2	3 months	42
Sundre	2	3 months	43
Valleyview	2	3 months	44
Waterton	8	3 months	45
Wimborne	4	3 months	46
Windfall	4	3 months	47

Table 2.7 Location of networks where fluoride is monitored on a static basis.

Network Location	# of Stations	Monitoring Period	Map Location
Calgary	3	1 month	**2**
Fort Saskatchewan	1	1 month	**22**
Medicine Hat	1	1 month	**7**
Redwater	4	1 month	**50**

included CO, COH, NO_x, NO, NO_2, O_3 SO_2, THC and suspended particulates (including TSP, BaP and Pb). Results from this monitoring program will be summarized in an independent Alberta Environment report.

Alberta Environment conducted a suspended particulate monitoring program in Drayton Valley during the autumn of 1989. This program was initiated in response to concerns voiced by local residents regarding a noticeable amount of wood and ash particulate fallout evident in Drayton Valley. Suspended particulates were monitored by a network of four high-volume samplers from September 5 to December 3, 1989 and one dichotomous sampler from November 10 to December 3, 1989. Suspended particulate data was analyzed for TSP, particle identification, and the quantification of the primary constituents of particulate loading. The results of this project are detailed in an independent report (Alberta Environment 1990).

A meteorological monitoring program commenced near the Town of Fort Saskatchewan in April 1988. The program is expected to be complete at the end of April 1991. The objectives of this project are to: (1) specify the diffusion climatology for the Fort Saskatchewan area; (2) make meteorological interpretations of high pollution episodes in the Fort Saskatchewan area; (3) provide high quality input data for dispersion models; and (4) determine differences in the air pollution potential between the Ellerslie and Fort Saskatchewan regions. A report summarizing the conclusions of this study is expected after the termination of the project.

2.5 MOBILE MONITORING UNITS

Alberta Environment operates four modified suburban trucks, equipped with H_2S and SO_2 monitors. One of these vehicles is also equipped to monitor THC. Alberta Environment also operates a self-contained mobile laboratory that is equipped to monitor for CO, COH, H_2S, NO_x, NO, NO_2, O_3, SO_2 and THC. This mobile laboratory also contains a gas chromatograph unit. Mobile monitoring surveys conducted in 1989 are summarized in Table 2.8.

Table 2.8 Mobile monitoring activities conducted by Alberta Environment in 1989.

Monitoring Survey	Survey Date	Survey Objectives	Parameters Monitored
Well blowout near Carrot Creek	Jan 16	Ensure public safety	CO, THC
Pelican Spruce Mills near Edson	Mar 6	Determine emission levels from teepee burner	CO, THC, NO, NO_2, NO_x, H_2S
Colin Energy well blowout near Eaglesham	Aug 14 to 16	Ensure public safety	SO_2, H_2S, THC
Petro Canada well leak at Windfall, near Whitecourt	Oct 18 and 19	Monitor emissions from a well leak and other sources in the area	SO_2, H_2S
British Petroleum pipeline leak near Redwater	Dec 19	Monitor emissions from a pipeline leak	SO_2, H_2S

2.6 ACID PRECIPITATION MONITORING NETWORK

Precipitation chemistry is monitored, on a one-month basis, at 13 locations in the province by Alberta Environment. The locations of acid precipitation monitoring stations are indicated in Figure 2-2. Precipitation chemistry samples are also collected at the High Prairie station on a daily basis. Laboratory analysis is conducted on precipitation samples to obtain the following parameters:

- pH;
- strong acidity;
- total acidity;
- specific conductance;
- sulphate (dissolved) as $SO_4^=$;
- nitrate as NO_3^-;
- ammonia as NH_4^+;
- chloride (dissolved) as Cl^-;
- ortho phosphate as $PO_4^=$;
- sodium as Na^+;
- potassium as K^+;
- calcium as Ca^{++} (dissolved); and
- magnesium as Mg^{++} (dissolved).

3. FACTORS AFFECTING AIR POLLUTION DISPERSION

The quality of the air is dependent on the quantity of pollutants emitted into the atmosphere and the ability of the atmosphere to disperse the pollutants. Air pollution transport and dispersion is influenced by the temperature structure of the atmosphere, turbulence in the atmosphere, wind direction and wind speed, and the changes in these elements introduced by local topography.

3.1 TURBULENCE

When the earth's surface is heated by the sun, pockets of warm air will form near the ground. This less dense, warm air will rise from ground-level to be replaced by cooler air. The cooler air is, in turn, heated and thus ascends creating convective turbulence. This vertical motion in the atmosphere becomes more intense as solar heating increases. Convective turbulence causes vigorous atmospheric mixing which allows air pollutants to disperse rapidly. During daylight hours, when winds are light to moderate, atmospheric overturning, or convection, is the dominant mechanism for pollutant dispersion.

Under high wind speeds, the frictional force of air movement over the ground will create mechanical turbulence. The greater the wind speed, the more mechanical turbulence that is generated. Mechanical turbulence is the dominant mechanism for atmospheric mixing on windy days and at night when convective mixing is negligible.

3.2 TEMPERATURE STRUCTURE

The temperature in the lower atmosphere may increase or decrease with height depending on the amount of energy received from the sun. As evening approaches, the ground experiences a net heat loss to the atmosphere. As the ground cools, the lower levels of the atmosphere will also cool. The vertical temperature profile is now the reverse of the daytime situation; i.e., temperature increases with height. Heat loss from the earth's surface causes a temperature inversion which will limit plume rise from pollution sources. Temperature inversions are common in the winter when heat from the sun is minimal. The persistence of temperature inversions over a long period of time will lead to increased concentrations of air pollutants in the lower atmosphere.

When solar heating or heating from man-made sources (e.g. the urban heat island) is strong enough, a shallow well-mixed layer will develop near the ground. This layer, which may be "capped" by a temperature inversion aloft, is known as the mixing layer. The depth of the mixing layer defines the volume of air in which air pollutants can be mixed. The lower the depth of the mixing layer, the less volume that is available to disperse air pollutants. A persistent lack of a mixing layer or a shallow mixing depth may lead to high air pollution episodes. The mixing layer is especially important in urban locations where large quantities of pollutants are released near ground level.

3.3 WIND

Wind direction and wind speed will determine the trajectory, or path, of air pollutants from source to receptor. Mechanical turbulence created by high wind speeds will enable more rapid dispersion of air pollutants released near ground-level. Air pollution emitted by elevated stack sources may actually be transported more rapidly to the ground and, therefore, lead to higher ground-level pollutant concentrations.

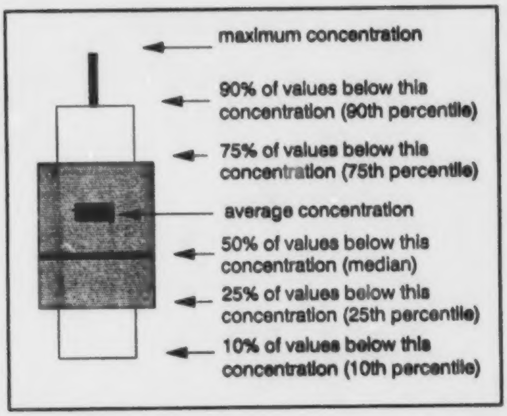
3.4 TOPOGRAPHY

The structure and orientation of terrain features will often influence and even control air motion and mechanical turbulence in the lower atmosphere. Small hills and trees may alter wind speed and direction while also enhancing mechanical turbulence. Larger terrain features such a mountains, hills and valleys may be a governing factor in the control of wind speed and wind direction. For example, wind may be diverted around large hills and mountains and channelled through valleys. Important diurnal variations of wind may also be caused by terrain features. A common cause for high pollution episodes is the occurrence of a persistant temperature inversion in a valley which contains numerous pollutant sources.

4. CONTINUOUS MONITORING RESULTS

Data analysis has been conducted on all parameters which are monitored continuously by Alberta Environment. A summary of the results of individual parameters collected by the continuous air quality network is preceded by a discussion of the Index of the Quality of the Air.

Concentrations of individual pollutants are summarized, on a monthly basis, in diagrams referred to as percentile diagrams or frequency distribution diagrams. An explanation of these diagrams is presented below:


maximum concentration
90% of values below this concentration (90th percentile)
75% of values below this concentration (75th percentile)
average concentration
50% of values below this concentration (median)
25% of values below this concentration (25th percentile)
10% of values below this concentration (10th percentile)

Analysis of trends of continuously monitored parameters is presented when at least four years of historical data are available. Trend analysis was conducted through the application of Daniel's Trend Test (U.S. Environmental Protection Agency 1974; World Health Organization 1980). This is a non-parametric sign-rank test which ranks observations from lowest to highest and compares the rank to the chronological order of the observations. From this, a value of the Spearman Rank Correlation Coefficient may be obtained. A trend is considered significant if the probability of the trend being correct is 95% or greater; that is a 95% level of confidence has been established.

4.1 INDEX OF THE QUALITY OF THE AIR

The Index of the QUality of the Air (IQUA) is a system that has been developed to report ambient concentrations of specific pollutants in a manner that can be easily understood by the general public. The IQUA was developed by a federal-provincial committee in 1978 and adopted by Alberta Environment in December of 1979.

One way to describe the quality of the air is to report the concentrations of each pollutant. However, this can be confusing and make interpretation difficult because each pollutant has different potential effects at different concentrations. The IQUA relates the effects of different pollutants to a common scale which may be easily understood by the general public.

The IQUA converts the measurements of five major pollutants (SO_2, O_3, CO, the COH, and NO_2) to a single rating and corresponding air quality description. An IQUA rating of 1 to 25 indicates Good air quality; 26 to 50 is Fair air quality; 51 to 100 is Poor air quality; and an IQUA rating greater than 100 indicates Very Poor air quality. For example, a rating of 30 (Fair) for two individual pollutants indicates the same degree of environmental impact for each individual pollutant. The specific effects themselves, however, will vary according to the pollutant.

With the exception of the COH, the air pollutant concentrations are linked to regulations under Alberta's Clean Air Act and the National Air Quality Objectives. These regulations and objectives consider the effects of different pollutants on human health, animals, vegetation, or general concerns such as odour and visibility. The IQUA rating categories are defined in the Table 4.1.

The IQUA for Edmonton and Calgary is available to the Alberta public and media twice each weekday. Recordings of the index are issued at 8:15 a.m. and 15:15 p.m., Monday through Friday in both cities. The index telephone number is 427-7273 in Edmonton and 250-2099 in Calgary. A total of 1209 calls were received by the IQUA telephone number at Edmonton in 1989. The highest frequency of calls was on March 9 when 47 calls were received. The IQUA on this day in Edmonton was Poor due to the coefficient of haze (visible dust and smoke in the atmosphere).

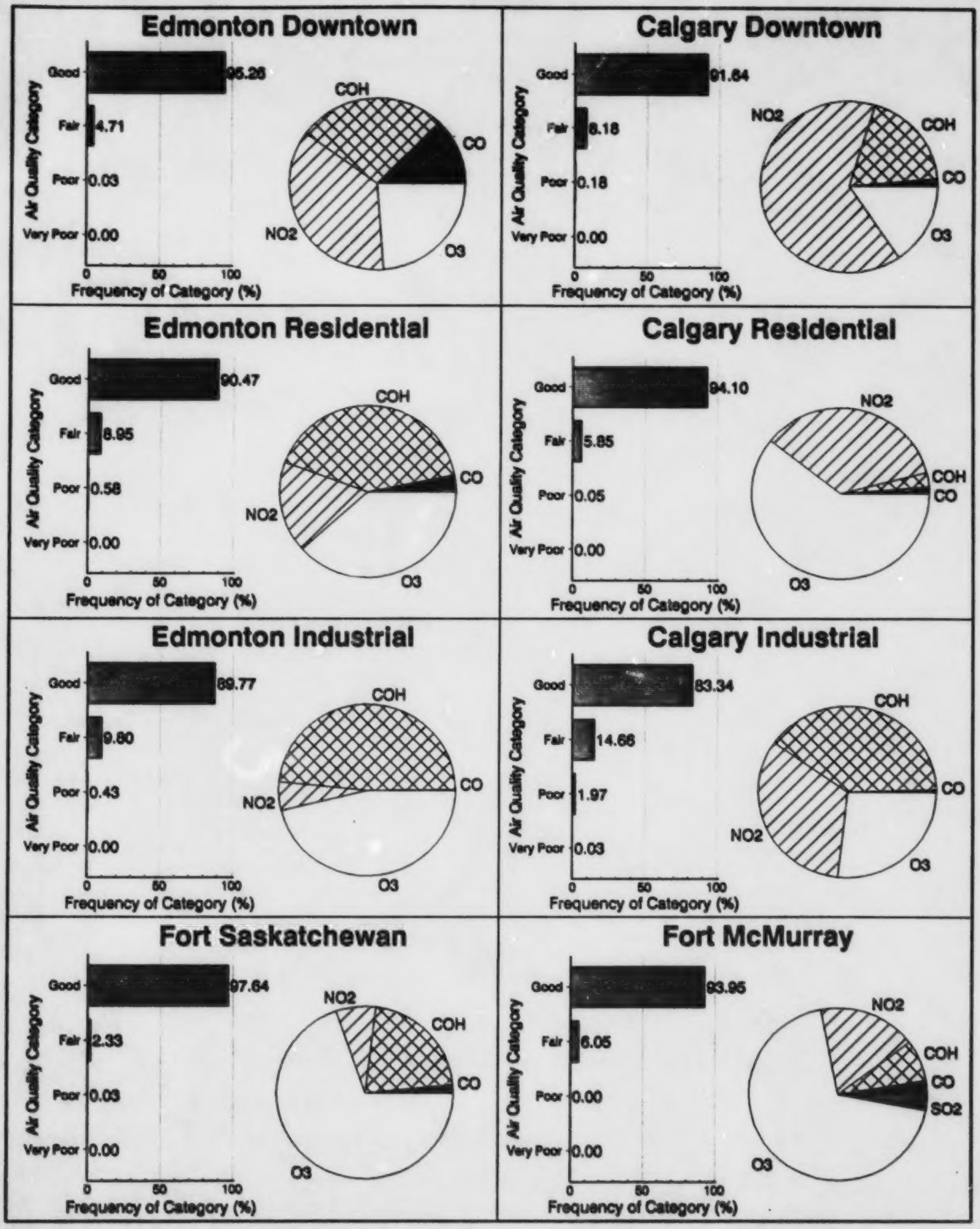
Table 4.1 Definition of IQUA rating categories.

IQUA rating	Frequency in Alberta	Effects
Good	almost all the time	Desirable range: no known harmful effects to soil, water, vegetation, animals, materials, visibility or human health. The long-term goal for air quality in Canada is to be in this range all the time.
Fair	occasional (typical when weather conditions inhibit pollutant dispersion)	Acceptable range: adequate protection against harmful effects to soil, water, vegetation, animals, materials, visibility and human health.
Poor	very seldom	Tolerable range: not all aspects of the environment are adequately protected from possible adverse effects. Long-term control action may be necessary, depending on the frequency, duration and circumstances of the readings.
Very Poor	very rare	Intolerable range: at this range, further deterioration of air quality and continued high readings could pose a risk to public health.

Source: Environment Canada (1980).

4.1.1 *Results*

The IQUA is calculated each hour and is summarized in monthly data reports for all Edmonton, Calgary, Fort Saskatchewan and Fort McMurray continuous air quality monitoring stations. At Fort MacKay, only SO_2, H_2S and THC are monitored on a continuous basis, therefore, the IQUA is not calculated. A summary of the frequency of the IQUA categories and the contribution of each pollutant to the IQUA category is presented for each monitoring station in Figure 4-1. A monthly frequency distribution of the IQUA category and pollutants that contribute to the IQUA category are illustrated in Figures 4-2 and 4-3, respectively.



Edmonton Downtown

Calgary Downtown

Edmonton Residential

Calgary Residential

Edmonton Industrial

Calgary Industrial

Fort Saskatchewan

Fort McMurray

Figure 4-1 Annual frequency distribution of the IQUA category and the pollutants that contribute to the IQUA for 1989.

Edmonton	427-7273
Calgary	250-2099

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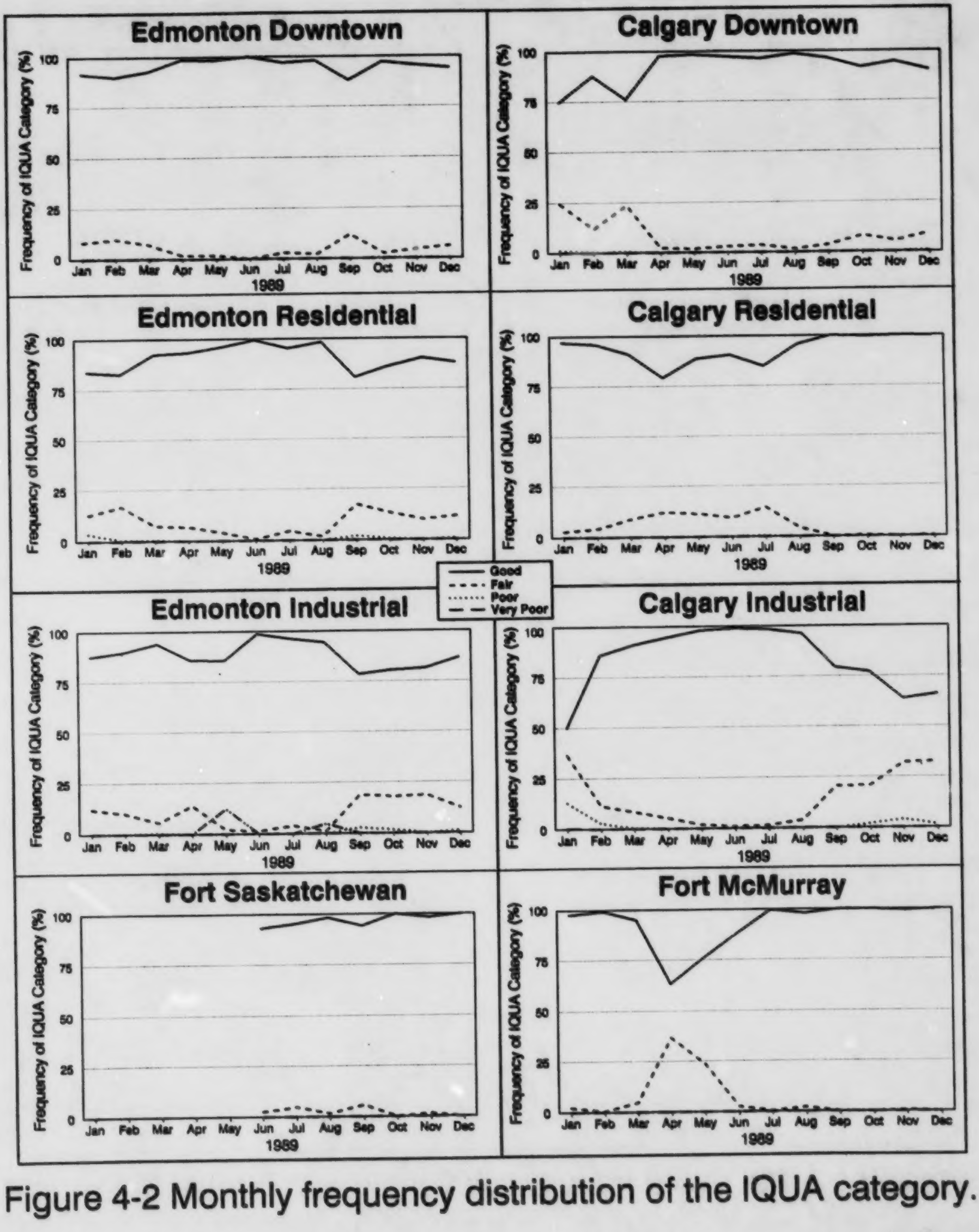

Figure 4-2 Monthly frequency distribution of the IQUA category.

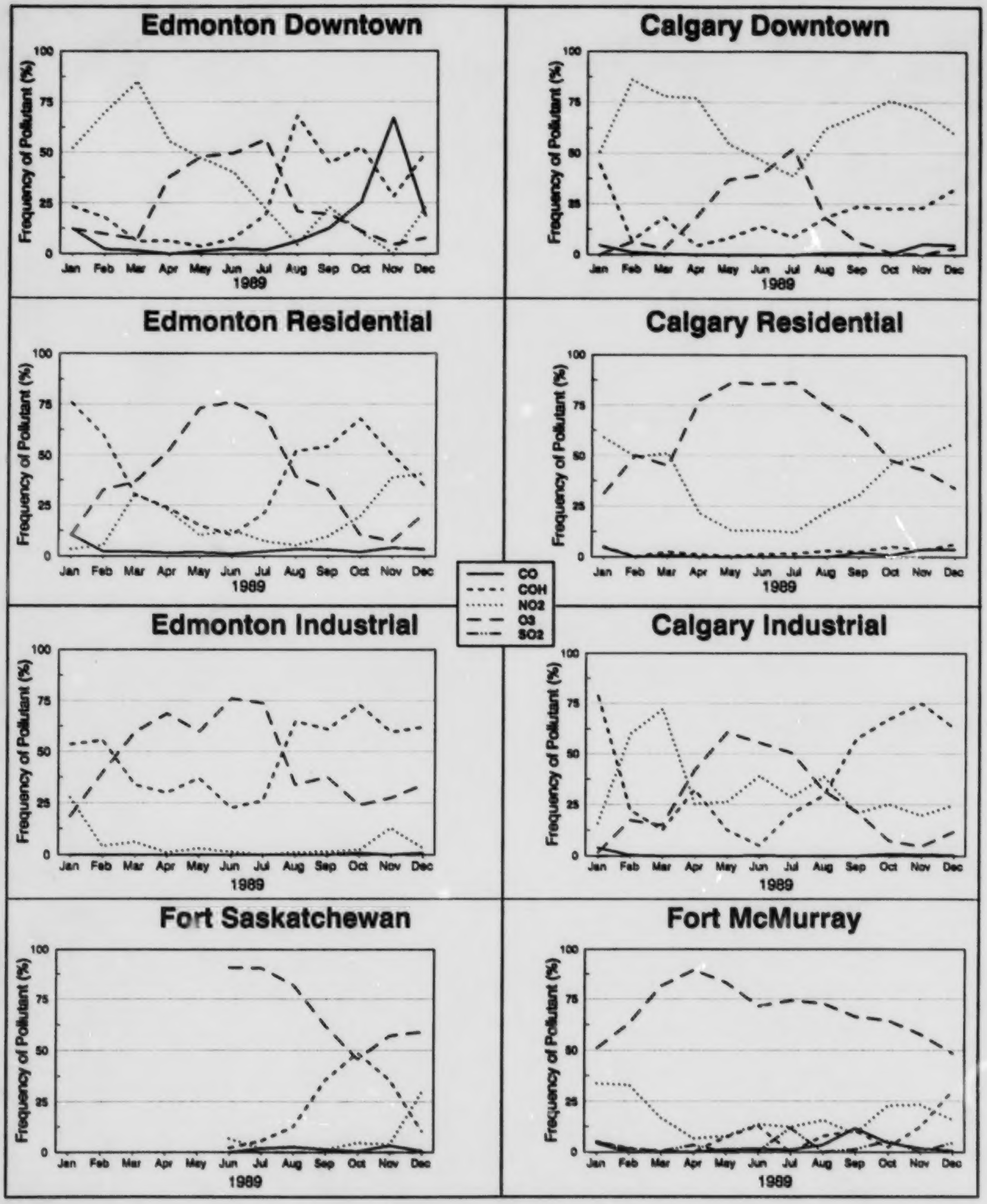

Figure 4-3 Monthly frequency distribution of pollutants contributing to the IQUA category.

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At all monitoring stations, the IQUA was Good for the majority of time in 1989. On an annual average basis, the IQUA was in the Good category from about 83% of the time at the Calgary industrial monitoring unit to 98% of the time at Fort Saskatchewan. It should be noted that only seven months of data are available at Fort Saskatchewan in 1989.

The number of IQUA readings in the Fair category ranged from about 2% at Fort Saskatchewan to 15% at the Calgary industrial monitoring unit. The IQUA readings were in the Poor category less than 1% at all locations, with the exception of the Calgary industrial monitoring location where close to 2% of air quality index readings were in the Poor category. Approximately 0.03%, or 3 hours, of the air quality index readings were in the Very Poor category at the Calgary industrial monitoring unit.

The pollutants responsible for the IQUA ratings are largely dependent on the location of the air quality station in relation to the source or sources. At locations where vehicle emissions were the predominant pollutant sources, NO_2, CO and the COH comprised the IQUA. At stations not situated near high traffic areas, O_3 is the most common pollutant. The vast majority of Poor and Very Poor air quality ratings at all monitoring stations are attributed to the COH, which is an indicator of the amount of dust and smoke in the atmosphere.

4.1.1.1 Edmonton

The IQUA was in the Good category most frequently in the spring and summer at Edmonton downtown and residential monitoring locations. At the industrial monitoring location, the IQUA was in the Good category most frequently from June to August. Fair and Poor air quality readings were most common during the autumn, winter and early spring at all Edmonton locations. The maximum number of Poor air quality readings were observed in January at the Edmonton residential monitoring unit where 3.5% of the readings were in the Poor category. No Very Poor air quality index ratings were recorded at any of the Edmonton monitoring locations in 1989.

At the Edmonton downtown monitoring location, the pollutants which contributed most frequently to the IQUA ratings were NO_2 (January to April) and O_3 (June and July). The COH is a major pollutant in August to October and December. CO was the major pollutant in November.

The COH was the primary contributor to the IQUA for the fall and winter months at the Edmonton residential monitoring unit. O_3 was a predominant pollutant from April to July. NO_2 contributed significantly to the IQUA in the early winter and spring.

At the Edmonton industrial monitoring unit, the COH was most common in the fall and winter; O_3 became the dominant pollutant in the spring and summer. CO and NO_2 contributed little to the IQUA at Edmonton industrial as compared to Edmonton downtown and residential locations.

4.1.1.2 *Calgary*

The IQUA was in the Good category over 90% of the time during: the spring, summer and autumn seasons at the Calgary downtown monitoring location; all months except April, May and July at the Calgary residential monitoring unit; and the spring and summer seasons at the Calgary industrial monitoring location. Fair air quality was most common from January to March at the downtown monitoring site. At the residential monitoring location, Fair air quality was most common from April to July.

Air quality deteriorated substantially in the fall and winter seasons at the Calgary industrial location, with only 50% of IQUA readings in the Good category in January. A Very Poor IQUA was observed 0.03% of the time at the Calgary industrial location in January due entirely to the COH. High COH measurements are likely due to the combination of vehicular emissions and stagnant meteorological conditions, such as temperature inversions, which inhibit pollutant dispersion.

NO_2 was the dominant pollutant from June to August at the Calgary downtown monitoring location. O_3 was a major pollutant contributing to the IQUA in the spring and summer months. The COH had a significant influence on air quality in the winter months at the Calgary downtown monitoring unit.

At the Calgary residential monitoring unit, NO_2 was the major contributor to the air quality index during the fall and winter seasons while O_3 was the major contaminant in the spring and summer. CO and the COH had only a minor influence on the IQUA at the Calgary residential location.

The COH was the was the major pollutant at the Calgary industrial monitoring location from September to January with NO_2 being the most common pollutant in February and March. As with the other monitoring locations, O_3 was the dominant pollutant in the spring and summer seasons. CO and SO_2 contribute very little to the IQUA at the Calgary industrial monitoring location.

4.1.1.3 *Fort Saskatchewan*

The air quality index was in the Good category over 90% of the time during all months that data is available (June to December) at the Fort Saskatchewan monitoring location. A Fair air quality index was most common from June to September. O_3 contributed most frequently to the IQUA for all months except October, where the COH was also prevalent. NO_2 influenced the IQUA in December. CO and SO_2 rarely contributed to the IQUA at Fort Saskatchewan in 1989.

4.1.1.4 *Fort McMurray*

The air quality index was in the Good category over 95% of the time from January to March and June to December at Fort McMurray. The greatest frequency of Fair IQUA readings is evident in April and May. The majority of IQUA readings were based on O_3 throughout the year, with a trend towards higher contributions in the spring and summer seasons. NO_2 and the COH also were important contributors to the air quality index.

4.2 WIND

4.2.1 Results

Wind speed and direction are routinely monitored at the 10-m level at the Edmonton residential and industrial, Calgary residential and industrial, Fort Saskatchewan, Fort McMurray and Fort MacKay monitoring locations. Wind data is not available at the Fort McMurray monitoring location in 1989 due to instrument error. The quality of the wind data collected at the Edmonton industrial monitoring location in 1989 is questionable and, therefore, will not be included in this analysis. Wind direction frequency distributions for Edmonton and Calgary monitoring stations, and Fort Saskatchewan and Fort MacKay monitoring stations are presented in Figures 4-4 and 4-5, respectively.

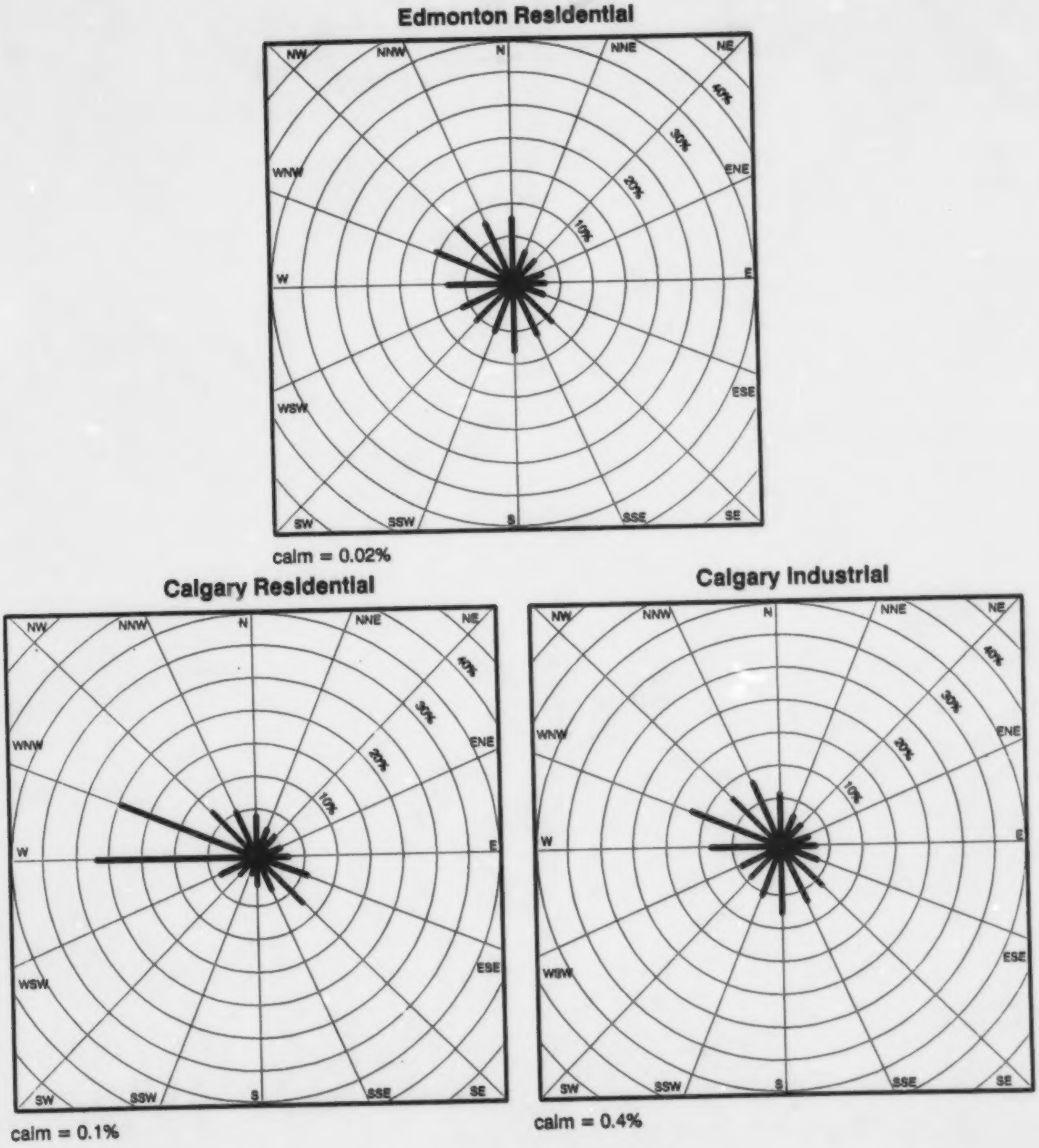
4.2.1.1 Edmonton

The most common wind directions at the Edmonton residential monitoring location in 1989 were from the west through to the north. The highest frequency of wind direction was 11% from the west-northwest direction. A small relative maxima was evident for winds from the southerly direction. Winds were relatively evenly distributed over the remaining wind directions.

4.2.1.2 Calgary

The highest frequency of winds at the Calgary residential location was from the west and west-northwest directions. Over 40% of the winds were from these two directions. Winds were evenly distributed over the remaining wind directions with a minor relative maxima noted for winds from the southeast.

Wind directions from the west to the west-northwest were the most common at the Calgary industrial monitoring location. The highest frequency of winds was 13% from the west-northwest direction. A minor maxima in wind direction was evident from the southeast to the south-southwest.



calm = 0.02%

calm = 0.1%

calm = 0.4%

note: wind not monitored at Edmonton and Calgary downtown stations

Figure 4-4 Frequency distribution of wind direction at Edmonton and Calgary monitoring locations.

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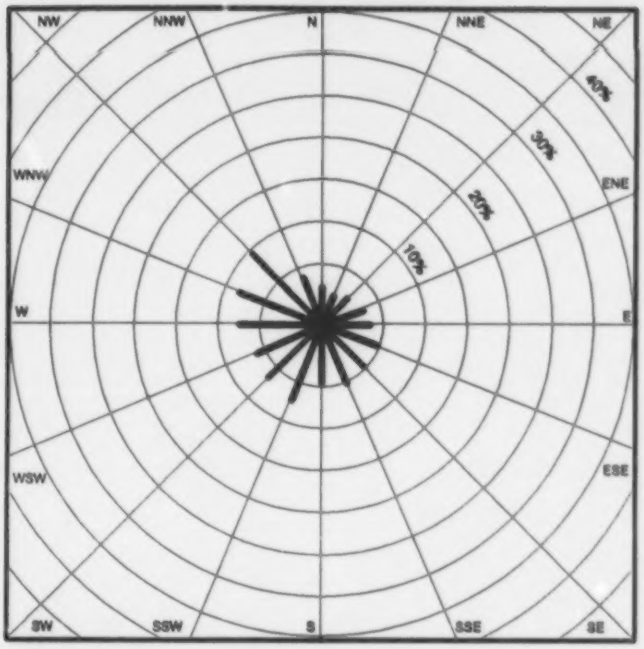
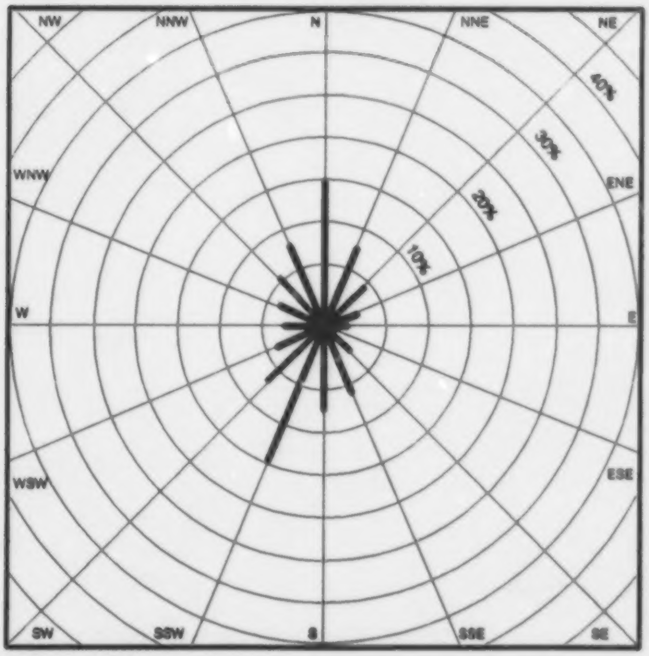
Fort Saskatchewan



calm = 11.6%

Fort MacKay



calm = 0.6%

Figure 4-5 Frequency distribution of wind direction at Fort Saskatchewan and Fort MacKay monitoring locations.

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4.2.1.3 Fort Saskatchewan

Wind direction and speed were monitored only during the months of June to December, 1989, at Fort Saskatchewan. Winds were predominantly from the south-southwest to the northwest during the monitoring period. Winds with a northeasterly component were least common at Fort Saskatchewan.

4.2.1.4 Fort MacKay

The highest frequency of wind directions at Fort MacKay were from the south-southeast to the southwest and the north-northwest to the north-northeast directions. Winds from the east and west directions were less frequent. This wind direction frequency distribution reflects the location of the Fort MacKay monitoring unit with respect to the Athabasca River valley which is situated in a north-south direction.

4.3 AMMONIA (NH_3)

4.3.1 Characteristics

NH_3 is a colourless gas with the well-known pungent odour found in household cleaners. NH_3 occupies a unique position as it is generally considered to be a desirable chemical, particularly in fertilizers, and not as a potential environmental pollutant. While NH_3 is produced both by natural and man-made sources, it is emitted mainly from natural sources through the decay of plant and animal material, animal waste, and a small portion is released during respiration. Of all the natural sources, by far the largest is from the degradation of dead plants and animals. The other major natural source of ammonia is animal by-products.

In Alberta, the fertilizer industry is the main industrial source of NH_3 (52%). The industry produces synthetic NH_3 for either direct application to the soils as a fertilizer or as a raw material in the production of other high nitrogen fertilizer products. The other major source of NH_3 is commercial feedlots where the large amounts of animal waste can be a significant source (40%).

4.3.2 *Method of Monitoring*

NH_3 is monitored continuously by the same principle as NO_2. In this method the air sample is split into two pathways. In the first, all NH_3 (as well as NO) in the sample is converted to NO by a catalyst and high temperatures (adding to the NO already in the sample). The concentration is measured by mixing the sample with O_3 and utilizing a chemiluminescence reaction to detect the amount of visible light produced. In the second pathway, at a temperature too low to convert NH_3, oxides of nitrogen are reduced to NO by a catalytic converter (adding to the NO already in the sample) and the chemiluminescence process repeated. The difference between the two readings is then calculated to be the concentration of NH_3.

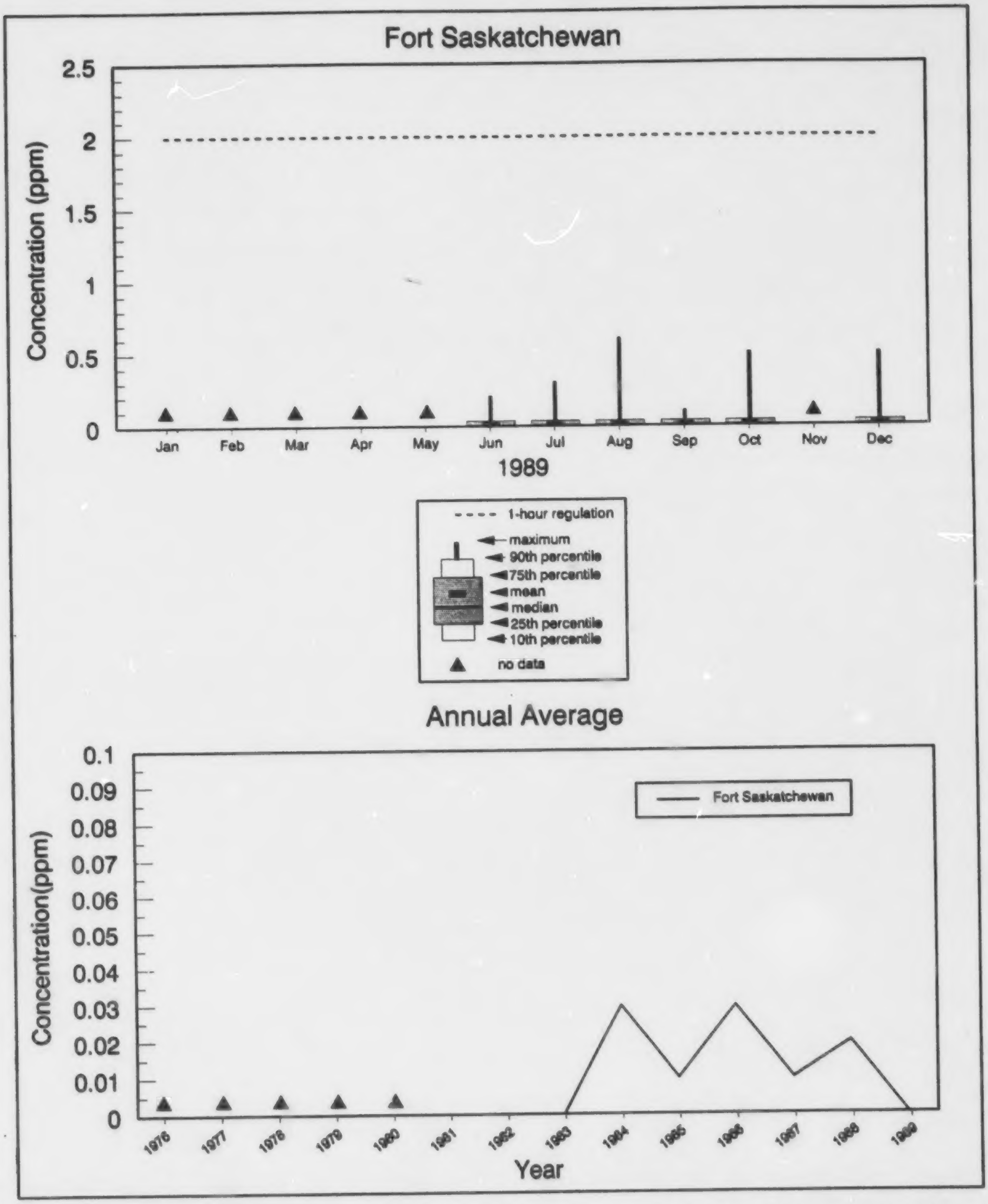
4.3.3 *Regulations and Guidelines*

Alberta Environment currently regulates NH_3 emissions by licencing each industrial source and limiting their emissions according to their Licence to Operate. In addition, each plant is required to monitor their emissions and report when ambient concentrations of NH_3 exceed 2.0 ppm as a 1-hour average.

4.3.4 *Results*

4.3.4.1 *Fort Saskatchewan*

NH_3 is monitored by Alberta Environment at the Fort Saskatchewan monitoring station because of its proximity to the fertilizer industry. Figure 4-6 shows a frequency distribution of NH_3 concentrations by month and annual average concentrations. Ambient NH_3 concentrations were below the detectable limit over 95% of the time for every month that data is available during 1989. A peak NH_3 concentration of 0.6 ppm was recorded in August. The 1-hour average regulation for NH_3 of 2.0 ppm was not exceeded at the Fort Saskatchewan monitoring station.



Fort Saskatchewan

Annual Average

Figure 4-6 Frequency distribution of ammonia concentrations at Fort Saskatchewan.

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4.4 CARBON MONOXIDE (CO)

4.4.1 *Characteristics*

CO, a common pollutant in urban areas, is a colourless, odourless gas. The majority of the CO found in urban air comes from incomplete combustion of carbon-based fuels. The primary source of urban CO is motor vehicles, with much smaller contributions from fireplaces, industrial sources, aircraft and natural gas combustion.

The relationship between vehicular traffic and CO is apparent at urban locations during morning and evening rush hours. CO concentrations also fluctuate seasonally. The highest concentrations occur during the late autumn, winter and early spring because: (1) in cold weather, motor vehicles run less efficiently; (2) vehicle warmup and idling times are increased; and (3) meteorological conditions, such as stable atmospheric conditions and low wind speeds result in decreased dispersion.

4.4.2 *Method of Monitoring*

CO is monitored continuously by either non-dispersive infrared photometry or gas filter correlation. The non-dispersive infrared photometry process is based upon the absorption of infrared light by CO. Gas filter correlation is operated on the same principle as non-dispersive infrared photometry and is also based on the absorption of infrared light by CO.

4.4.3 *Regulations and Guidelines*

The regulations governing the maximum permissible concentration of CO are based on the prevention of human health effects. In regulating CO, Alberta has adopted Environment Canada's most rigorous ambient air quality regulations. Maximum permissible CO concentrations are:

- 13.0 ppm as a 1-hour average concentration; and
- 5.0 ppm as an 8-hour average concentration.

4.4.4 ***Results***

CO was monitored, on a continuous basis, at all three Edmonton and Calgary air quality stations, and at the Fort Saskatchewan and Fort McMurray monitoring stations. Frequency distributions of monthly CO concentrations and annual average CO concentrations are illustrated in Figures 4-7 to 4-9. In 1989, annual average CO concentrations ranged from 0.44 ppm at Fort Saskatchewan to 1.65 ppm at the Edmonton downtown monitoring unit. The highest annual average concentrations were observed at the Edmonton and Calgary downtown locations.

CO concentrations are generally higher in the autumn and winter months than the spring and summer months. In the winter, temperature inversions are more likely to persist throughout the day due to a lack of solar heating. Persistent inversions coupled with longer vehicular warmup and idling times lead to increased CO concentrations during the late autumn and winter months. In Calgary, high pollution episodes are most likely the result of pollutants trapped near the ground prior to a chinook.

A well-defined diurnal variation of CO concentrations was evident at most air quality monitoring stations. CO peaks are evident during the morning and afternoon traffic rush hours. Minimum CO values are generally recorded overnight when vehicular traffic is at a minimum.

4.4.4.1 ***Edmonton***

A total of four and five hours exceeded the 1-hour average regulation for CO at the Edmonton downtown and residential monitoring locations, respectively. The maximum 1-hour average CO concentration observed in Edmonton during 1989 was 25.4 ppm which was recorded at the Edmonton residential monitoring unit in January. This peak value is approximately twice the 1-hour regulation of 13 ppm for CO.

The 8-hour average regulation for CO, was exceeded nine times at the Edmonton downtown monitoring unit and three times at the Edmonton residential monitoring units. Most of the exceedances were recorded in November to March with exceedances also indicated in September at both locations. The maximum number of exceedances of the 8-hour regulation occurred in November at the Edmonton downtown monitoring unit. The

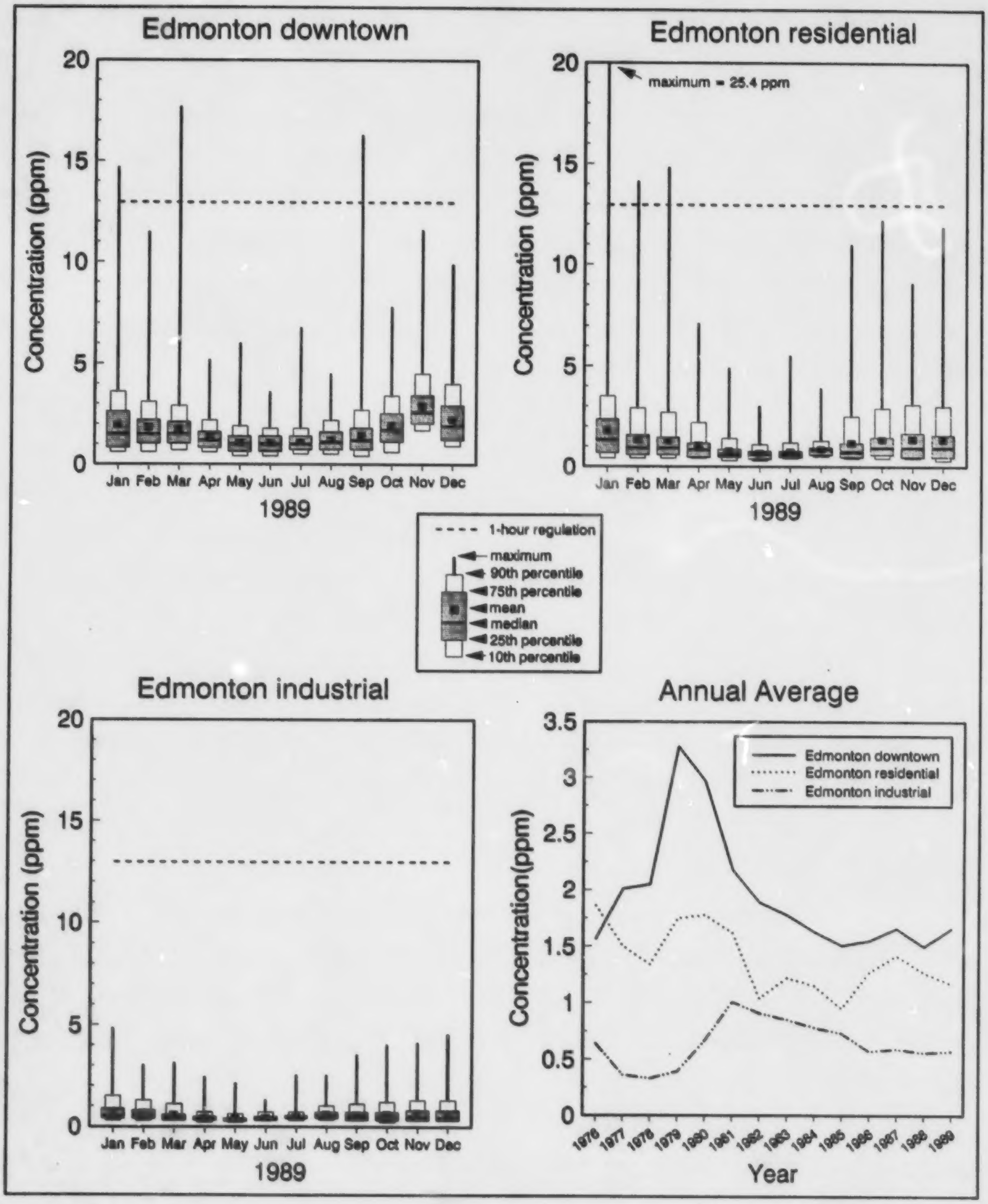

Figure 4-7 Frequency distribution of carbon monoxide concentrations at Edmonton.

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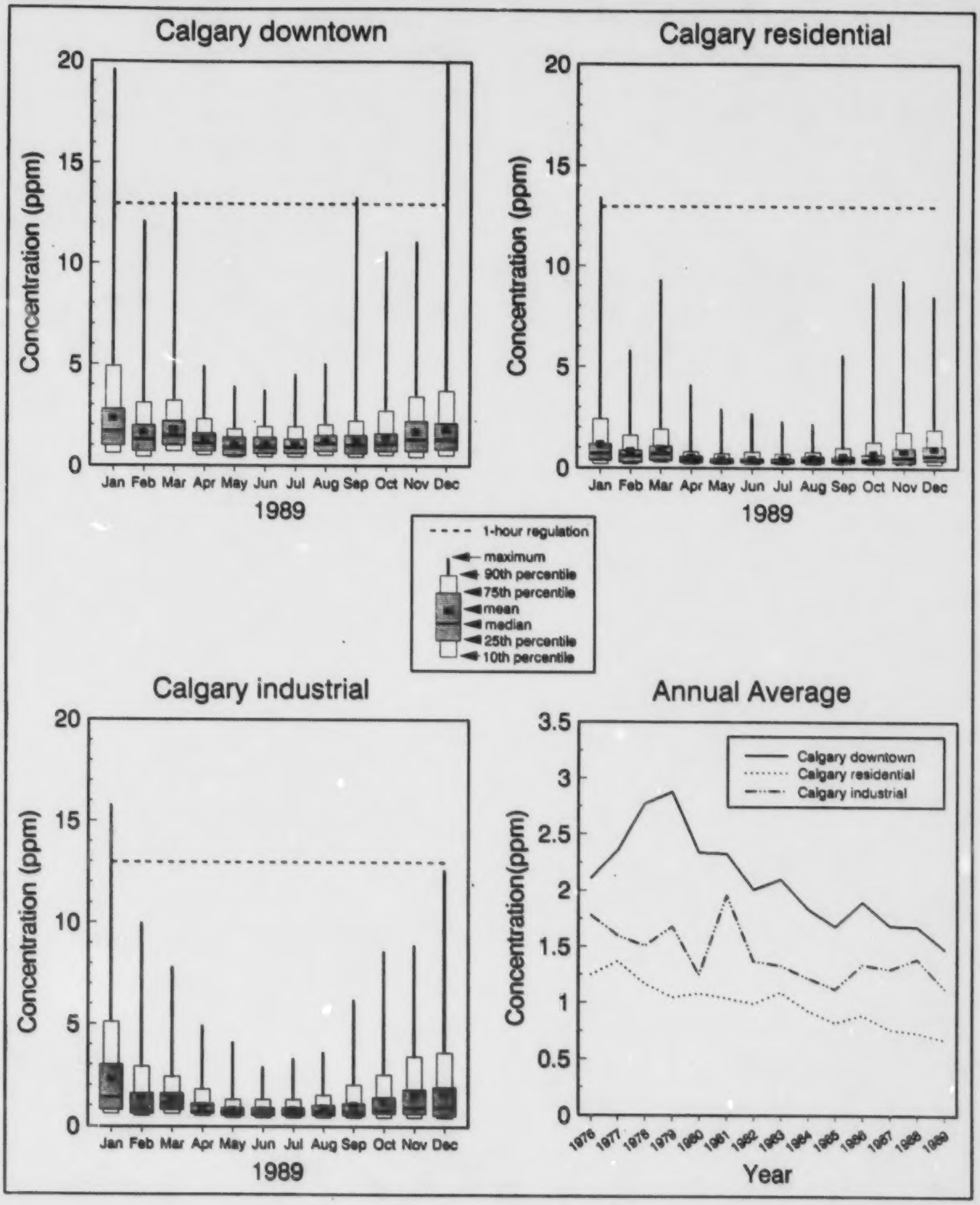

Figure 4-8 Frequency distribution of carbon monoxide concentrations at Calgary.

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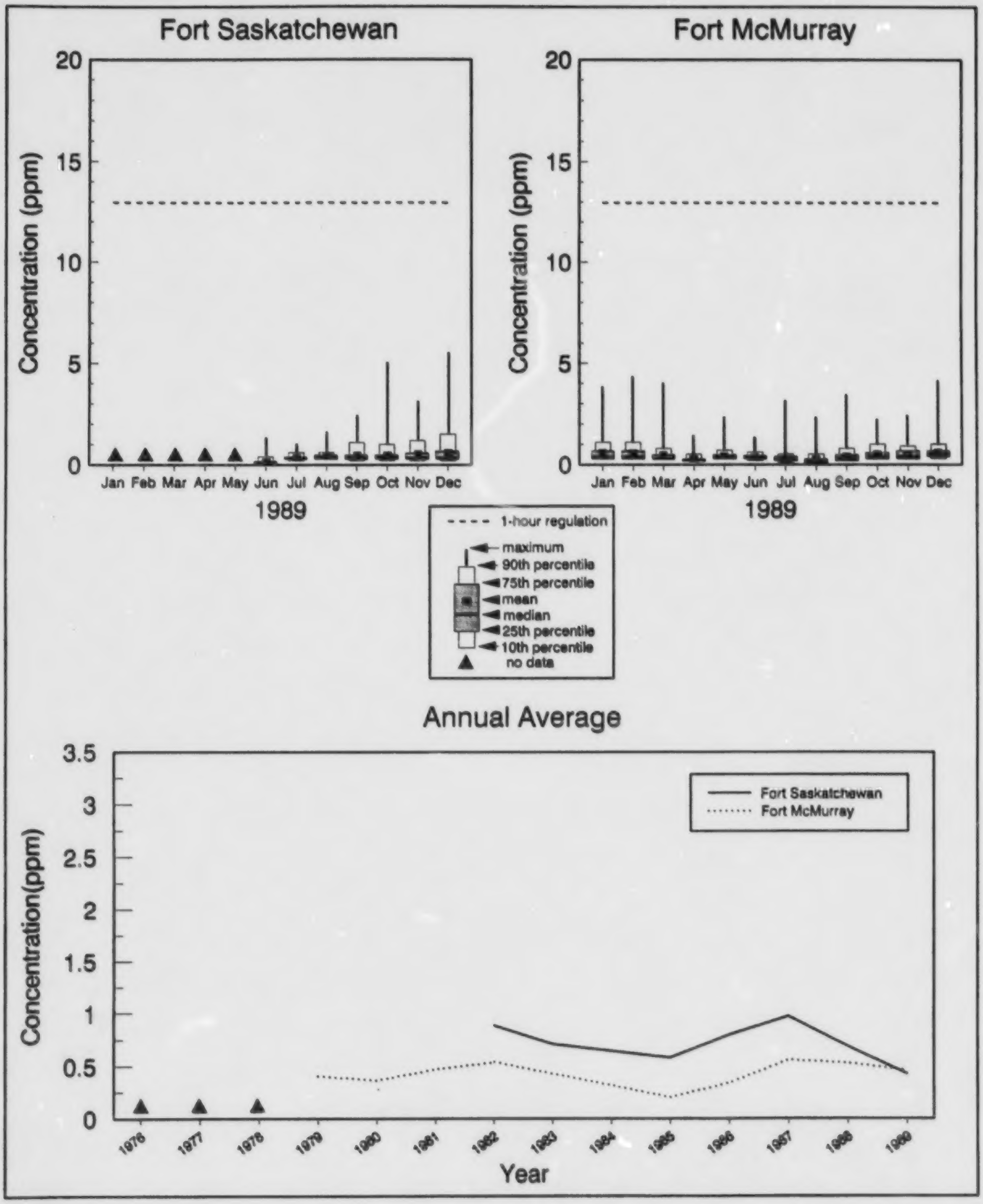

Figure 4-9 Frequency distribution of carbon monoxide concentrations at Fort Saskatchewan and Fort McMurray.

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8-hour regulation was exceeded on three occasions in this month. A maximum 8-hour average CO concentration of 8.3 ppm was observed in January at the downtown monitoring unit.

Typically, the downtown station, with its higher vehicle density, tended to have higher average CO levels than the other two stations. However, because the residential station is located in an area bounded by several major traffic arteries, relatively high CO concentrations were also recorded at this location. One-third of the exceedances at the residential monitoring station were contributed when winds were from the westerly quadrants. This is the direction of a major traffic artery (i.e., 127 St.) in the vicinity.

A downward trend in annual average CO concentrations is indicated at the Edmonton downtown and residential monitoring stations. This downward trend may be attributed to lower emissions from vehicles, more efficient automobile engines and less older vehicles on the road.

4.4.4.2 *Calgary*

Exceedances of the 1-hour regulation for CO were noted at all Calgary monitoring stations. Exceedances were most common during January, March, September and December at the Calgary downtown monitoring unit. The 1-hour average CO concentration exceeded the regulation a total of 12 times at the Calgary downtown monitoring station, 4 times at the industrial monitoring station and once at the residential monitoring station. The peak hourly-average value was 21.3 ppm which was recorded in December at the Calgary downtown location.

The 8-hour regulation was exceeded a significant number of times, especially during the winter season at the Calgary downtown and industrial monitoring units. The 8-hour regulation was exceeded 17 times at the Calgary downtown monitoring station, 13 times at the industrial monitoring station and once at the residential monitoring station. A maximum frequency of exceedances of 8.7 percent (8 episodes) was noted at each of the Calgary industrial and downtown monitoring units in January. A peak 8-hour average of 13.2 ppm was observed at the downtown monitoring station in January.

The highest average and peak CO concentrations were recorded at the Calgary downtown station. These hourly readings occurred during the rush hour on days with stagnant meteorological conditions (temperature inversions).

A significant downward trend in the annual average concentration of CO is evident at all Calgary monitoring stations. This trend may be due to decreased vehicular emissions of CO.

4.4.4.3 *Fort Saskatchewan*

The 1- and 8-hour regulations for CO were not exceeded at the Fort Saskatchewan monitoring unit in 1989. Peak 1- and 8-hour average CO concentrations were 5.5 and 2.8 ppm, respectively. The maximum 1-hour average concentration was observed in December. A significant trend in annual average CO concentrations is not evident at the Fort Saskatchewan monitoring location.

4.4.4.4 *Fort McMurray*

Exceedances of the 1- and 8-hour regulations were not observed at the Fort McMurray monitoring unit in 1989. Maximum 1- and 8-hour average values for CO of 4.3 and 2.6 ppm, respectively, were observed at the Fort McMurray monitoring station. Annual average CO data collected at Fort McMurray does not show a significant historical trend.

4.5 COEFFICIENT OF HAZE (COH)

4.5.1 *Characteristics*

The interaction of particles with sunlight and atmospheric moisture can result in diminished visibility (haze). The coefficient of haze is an index which corresponds to the reduction of transmitted light, or visibility reduction, due to particulate matter in the form of dust and smoke.

4.5.2 *Method of Monitoring*

Air samples are collected continuously by drawing a known volume of air through a filter paper for a period of one hour. The soiling properties of the sample are measured by the reduction of light transmission through the filter tape. This reduction is reported as the coefficient of haze per 1000 linear feet of air sample. This method does not measure the absolute concentration or deposited mass of particulates but rather is an index of fine suspended particulate matter in the air.

4.5.3 *Regulations and Guidelines*

Guidelines regarding the COH are based on visibility reduction. Alberta Environment has established that:

- 90% of the COH readings per month shall be less than 1.0 COH unit.

4.5.4 *Results*

In 1989, the COH was monitored at all Edmonton, Calgary, Fort Saskatchewan and Fort McMurray monitoring units. Annual average COH indices ranged from 0.06 COH units at Fort McMurray to 0.28 COH units at the Calgary industrial monitoring location. The COH was higher at the Edmonton and Calgary industrial locations and lower at the more rural locations of Fort Saskatchewan and Fort McMurray.

All stations show a seasonal trend with higher COH levels during the winter and autumn months. Meteorological conditions in the winter and autumn months are often favourable for the accumulation of pollutants within the lower atmosphere. The largest source of urban particulates is likely automobile emissions. Emissions from industrial sources and dust from the streets in the winter and early spring also are significant sources.

Substantial maximums in COH values were recorded during the morning and afternoon rush hours at the Calgary and Edmonton monitoring stations. This diurnal tendency is not as prevalent at the Fort Saskatchewan and Fort McMurray monitoring stations. Frequencies of monthly COH values and are presented in Figures 4-10 to 4-12. The trends of annual average COH values are also illustrated in these figures.

4.5.4.1 *Edmonton*

All three Edmonton stations recorded at least 90% of the COH readings per month less than the guideline level of 1.0 COH. Values which exceeded 1.0 COH unit occurred most frequently at the Edmonton residential and industrial monitoring stations. About 6% of COH values exceeded 1.0 COH unit during September at the Edmonton

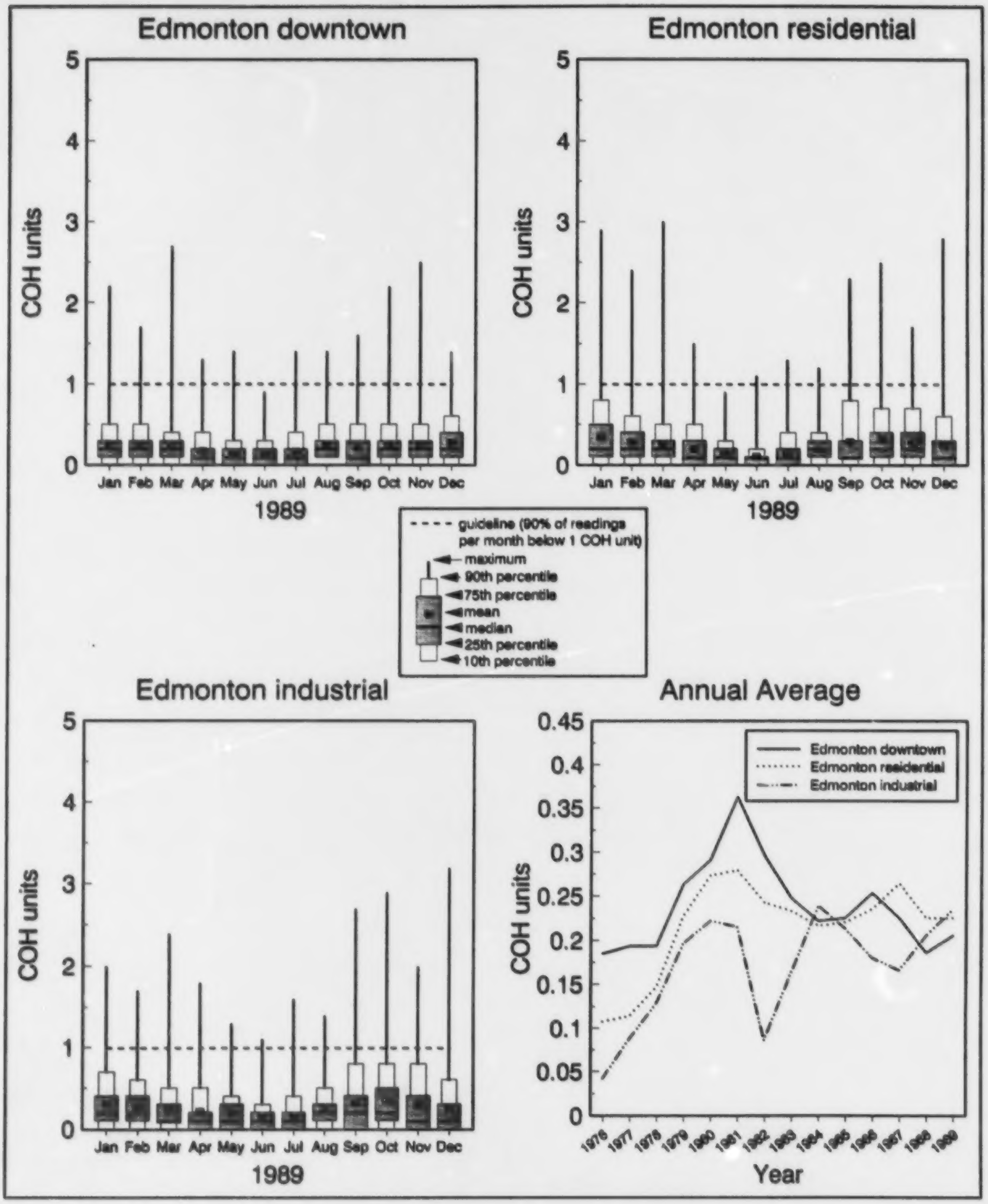

Figure 4-10 Frequency distribution of the coefficient of haze at Edmonton.

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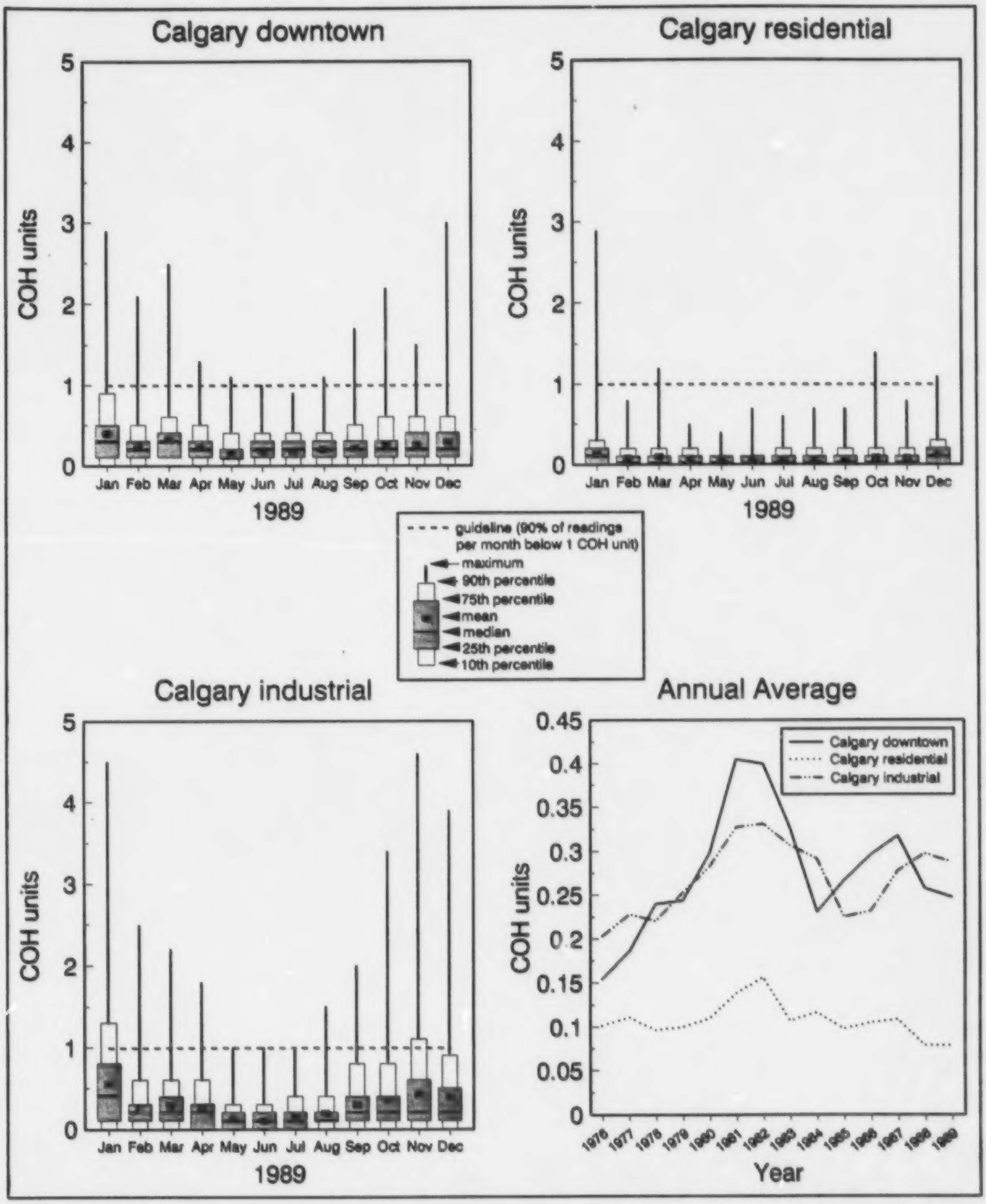

Figure 4-11 Frequency distribution of the coefficient of haze at Calgary.

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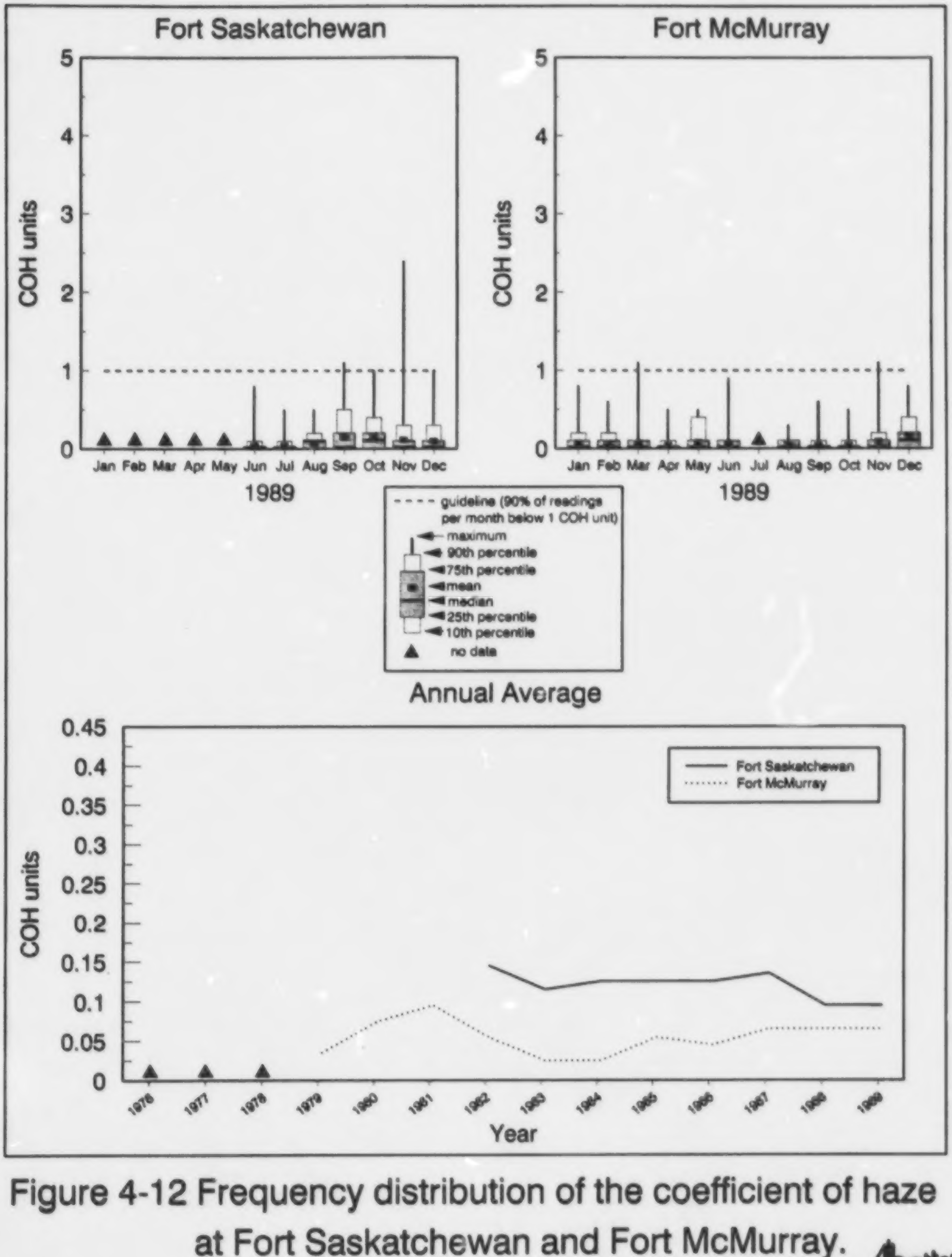

Figure 4-12 Frequency distribution of the coefficient of haze at Fort Saskatchewan and Fort McMurray.

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residential monitoring location and during September and November at the Edmonton industrial monitoring location. A maximum COH reading of 3.2 COH units was observed in December at the Edmonton industrial monitoring unit. A significant increase in annual average COH values is evident at the Edmonton industrial monitoring location. A significant trend is not evident at the other Edmonton monitoring stations.

4.5.4.2 Calgary

Exceedances of the guideline for the COH were recorded in January and November at the Calgary industrial monitoring unit. A total of 15% and 12% of observations exceeded 1.0 COH unit for these two months, respectively. A maximum COH value of 4.6 was recorded at the industrial monitoring location in November. Much higher COH values were observed at the Calgary industrial and downtown monitoring locations than at the Calgary residential monitoring station. The major source of particulates at the downtown monitoring location likely is vehicular emissions. The most probable source of high COH values at the industrial monitoring location is the transport of pollution from the downtown core. Significant trends in annual average COH values were not observed at any Calgary monitoring locations.

4.5.4.3 Fort Saskatchewan

Exceedances of the guideline for the COH did not occur at the Fort Saskatchewan monitoring station in 1989. The highest frequency of values which exceeded 1.0 COH unit was 0.15% which occurred in November. A maximum index of 2.4 COH units was recorded in November. A trend in annual average COH is not detectable at the Fort Saskatchewan monitoring station.

4.5.4.4 Fort McMurray

The maximum COH value recorded in Fort McMurray was 1.1 COH units. The guideline for COH was not exceeded in Fort McMurray during 1989. The highest frequency of values that exceeded 1.0 COH unit was 0.2% which occurred in March. Annual average COH values do not show a trend at Fort McMurray.

4.6 HYDROGEN SULPHIDE (H_2S)

4.6.1 *Characteristics*

H_2S is a colorless gas with a characteristic "rotten egg" odour. The gas is heavier than air and therefore concentrations tend to remain near the earth's surface. H_2S is produced both naturally and through industrial processes. H_2S is found naturally in coal, natural gas, oil, sulphur hot springs, sloughs, swamps and lakes. This decomposition is responsible for the rotten egg odour commonly associated with marshes, sewers, and sewage lagoons.

While most of the H_2S in the atmosphere is from natural sources, industrial sources have a significant impact on the environment. These industrial sources are primarily petroleum refining plants, natural gas refining plants, petrochemical complexes, coke oven plants, and pulp and paper mills employing the kraft pulping process.

4.6.2 *Method of Monitoring*

H_2S is measured continuously by pulsed fluorescence. In this method, air is drawn through a sample chamber where it is irradiated with pulses of ultra-violet light. Any H_2S in the sample is excited to a higher energy level and upon returning to is its original state, light or fluorescence is released. The amount of fluorescence measured is proportional to the H_2S concentration.

4.6.3 *Regulations and Guidelines*

The regulations governing the maximum permissible concentration of H_2S is based on the odour threshold although, many individuals can smell H_2S at levels below the ambient regulations. In regulating H_2S, Alberta has adopted Environment Canada's most rigorous ambient regulation with a maximum permissible concentration of:

- 0.010 ppm as a 1-hour average concentration; and
- 0.003 ppm as a 24-hour average concentration.

4.6.4 Results

H_2S is monitored at the Calgary industrial, Fort Saskatchewan, Fort McMurray and Fort MacKay monitoring units. Percentile diagrams for monthly concentrations and annual average concentrations from these stations are presented in Figures 4-13 and 4-14. The highest annual average H_2S concentration of 0.001 ppm was recorded at the Calgary industrial monitoring station. All other stations recorded 0.000 ppm as an annual arithmetic average. Because H_2S concentrations were low at most locations, seasonal, diurnal and annual trends were not distinguishable. However, episodic exceedances of the 1- and 24-hour regulations were observed.

4.6.4.1 Calgary

Exceedances of the 1- and 24-hour standard for H_2S were detected at the Calgary industrial monitoring station. A total of five hours exceeded the 1-hour regulation of 0.010 ppm. These exceedances were observed in January, November and December. A total of four days exceeded the 24-hour regulation of 0.003 ppm for H_2S. Maximum 1- and 24-hour average H_2S concentrations recorded at the Calgary industrial monitoring station were 0.015 ppm and 0.005 ppm, respectively.

Wind directions during episodes that exceeded the 1-hour standard for H_2S were from the north-northeast and east-northeast directions. Sources of exceedances are likely Calgary's main sewage treatment plant and other fugitive emissions from industrial sources in the vicinity. Strong temperature inversions were present during these episodic exceedances.

4.6.4.2 Fort Saskatchewan

H_2S concentrations did not exceed the 1- or 24-hour regulations at the Fort Saskatchewan monitoring location. Maximum 1- and 24-hour average concentrations were 0.004 and 0.001 ppm, respectively. These values are 40% and 33% of the 1- and 24-hour regulations for H_2S, respectively. Sources of H_2S in the region are likely fugitive emissions from local petroleum refineries and sewage lagoons located in northeast Edmonton.

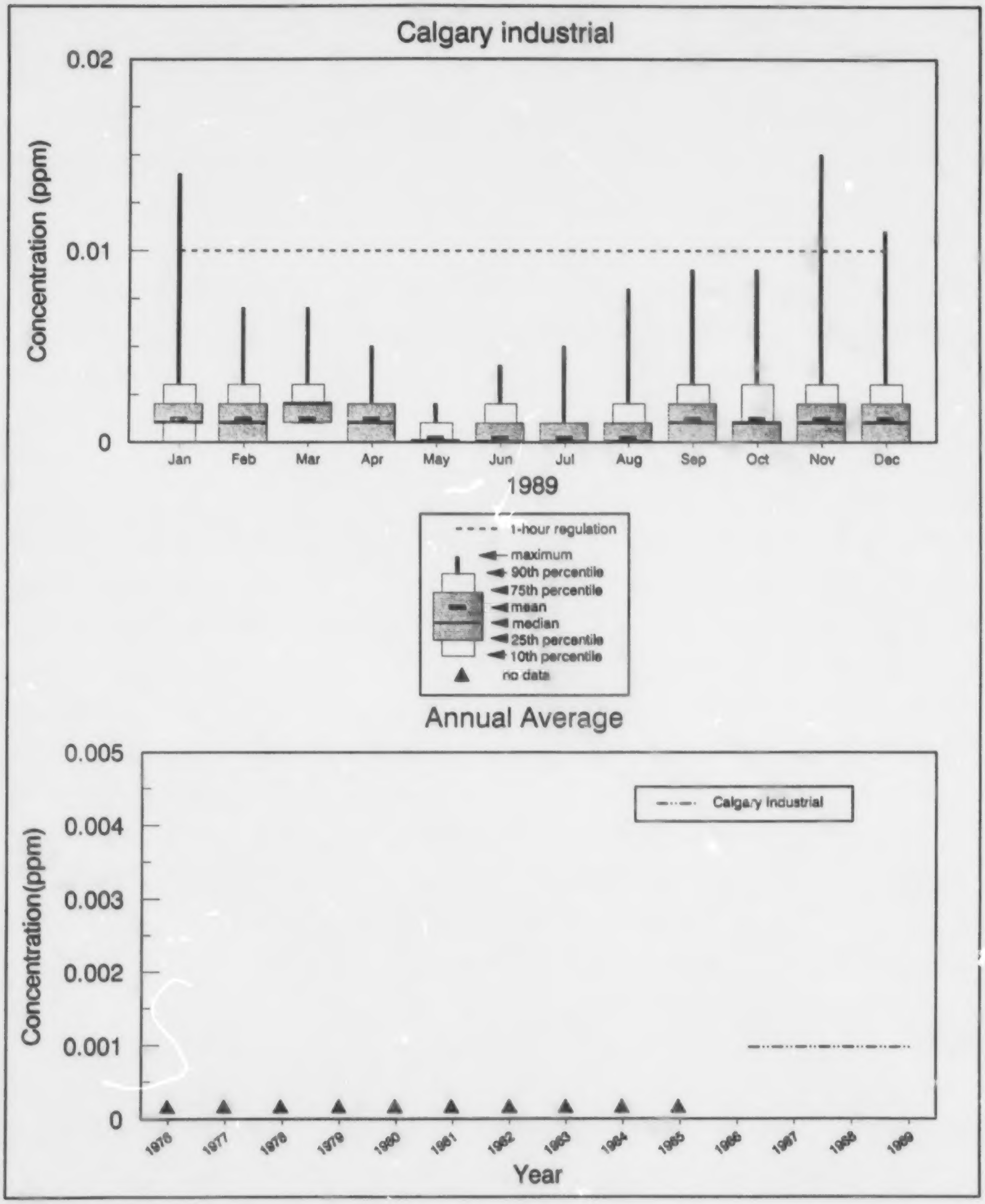

Figure 4-13 Frequency distribution of hydrogen sulphide concentrations at Calgary.

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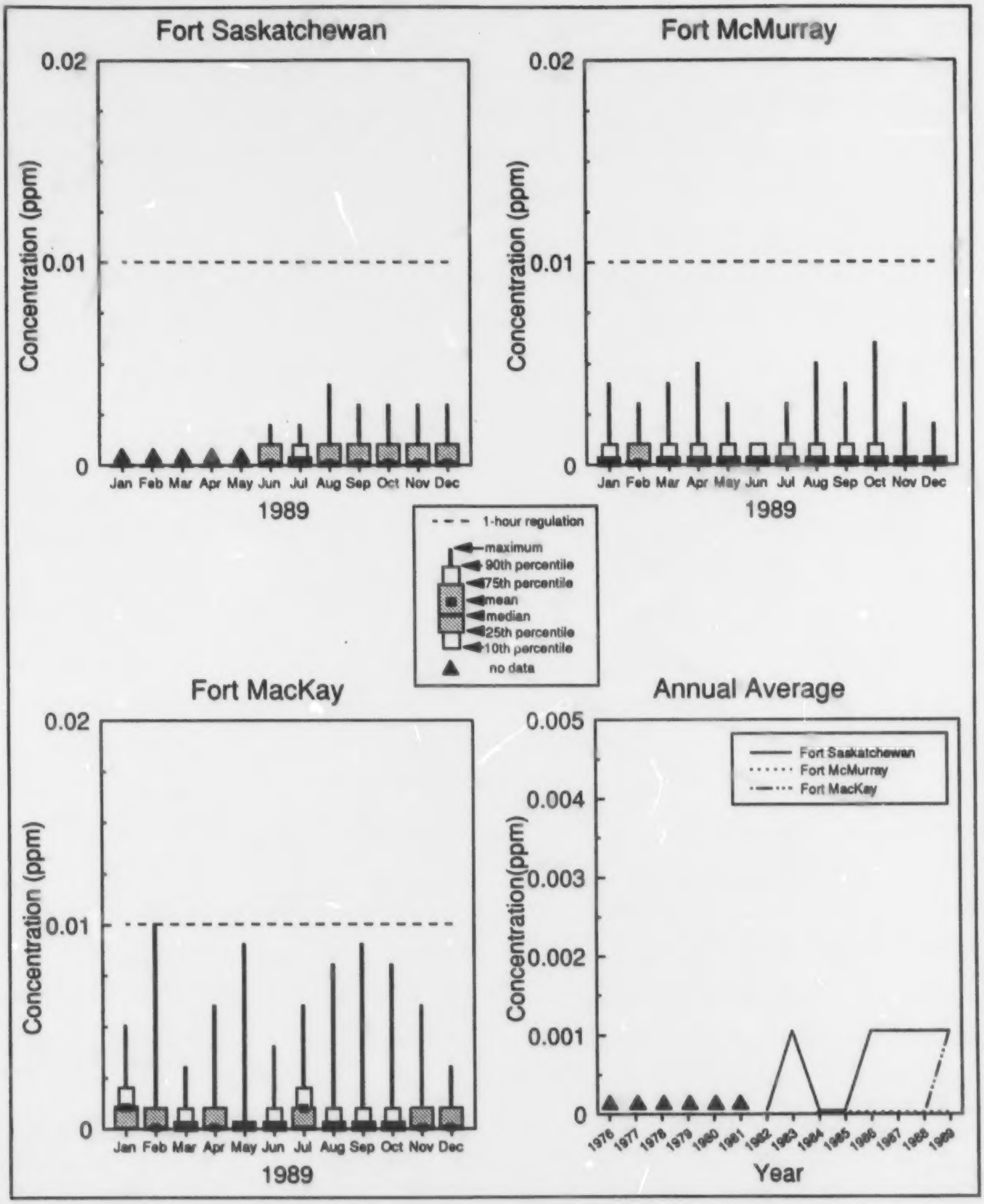

Figure 4-14 Frequency distribution of hydrogen sulphide concentrations at Fort Saskatchewan, Fort McMurray and Fort MacKay.

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4.6.4.3 Fort McMurray and Fort MacKay

H_2S levels monitored at the Fort McMurray and Fort MacKay air quality stations were generally well below the 1- and 24-hour regulations. Maximum 1-hour average H_2S concentrations at the Fort McMurray and Fort MacKay monitoring stations were 0.006 and 0.010 ppm, respectively. Maximum 24-hour average concentrations of H_2S at these two locations were 0.002 ppm and 0.003 ppm, respectively. These stations are located in the vicinity of large oil sands facilities where fugitive emissions of H_2S are common from the processing of bitumen into crude oil.

4.7 OXIDES OF NITROGEN (NO_x)

4.7.1 Characteristics

Oxides of nitrogen appear in the ambient atmosphere as nitrogen dioxide (NO_2), nitrogen oxide (NO) and nitrous oxide (N_2O). Alberta Environment monitors for NO_2, NO, and NO_x on a continuous basis.

During high temperature combustion, as in the burning of natural gas, coal, oil and gasoline, atmospheric nitrogen may combine with molecular oxygen to form NO. NO is colourless, odourless and has no known toxic effects. Most of the NO is rapidly oxidized to form NO_2. NO_2 is a reddish-brown gas with a characteristic pungent odour. NO_2 is partially responsible for the brownish discolouration of the lower atmosphere near urban areas.

Nitrous oxide is a naturally occurring, sweet smelling, non-toxic gas in the ambient atmosphere. For the purposes of air quality monitoring, total oxides of nitrogen (NO_x) is considered to be the sum of the concentration of NO_2 and NO. Nitrous oxide is not included as a contributor to total oxides of nitrogen in ambient air quality monitoring because ambient concentrations are generally very low.

In Alberta, about 38% of NO_x emissions are contributed by the oil and gas industry, 29% by transportation and 16% by power plants. The remaining 17% originate from natural gas and heating fuel combustion, agricultural fuel consumption and other industries (Alberta Environment 1990).

4.7.2 *Method of Monitoring*

Oxides of nitrogen are measured continuously by the principle of chemiluminescence. In this method, the air sample is split into two pathways. In the first pathway, the NO concentration is measured by mixing ozone with the sample and detecting the amount of visible light produced when the NO reacts with the O_3. In the second pathway, all the NO_2 in the sample is reduced to NO by a catalytic converter. The difference between the two readings is the concentration of NO_2.

4.7.3 *Regulations and Guidelines*

The regulations governing the maximum permissible concentration of NO_2 are based on the prevention of human health effects. In regulating NO_2, Alberta has adopted the most rigorous ambient regulations set by Environment Canada with a maximum average concentration of:

- 0.21 ppm as a 1-hour average concentration;
- 0.11 ppm as a 24-hour average concentration; and
- 0.03 ppm as an annual arithmetic average.

There are no regulations for ambient concentrations of NO and NO_x.

4.7.4 *Results*

NO_2, NO and NO_x are monitored routinely at all Edmonton, Calgary, Fort Saskatchewan and Fort McMurray monitoring sites. Because NO and NO_x are monitored for the purpose of determining concentrations of NO_2, only NO_2 will be discussed in this section. Figures 4-15 to 4-17 show monthly frequency distributions for NO_2 at each monitoring location. Annual average concentrations are also presented in these figures.

In 1989, annual average NO_2 concentrations ranged from 0.009 ppm at Fort Saskatchewan to 0.035 ppm at the Calgary downtown monitoring unit. Downtown monitoring units at both Edmonton and Calgary measured the highest annual average NO_2 values. This is mainly due to a higher density of vehicular traffic and also the usage of heating fuels in the downtown cores of the two cities.

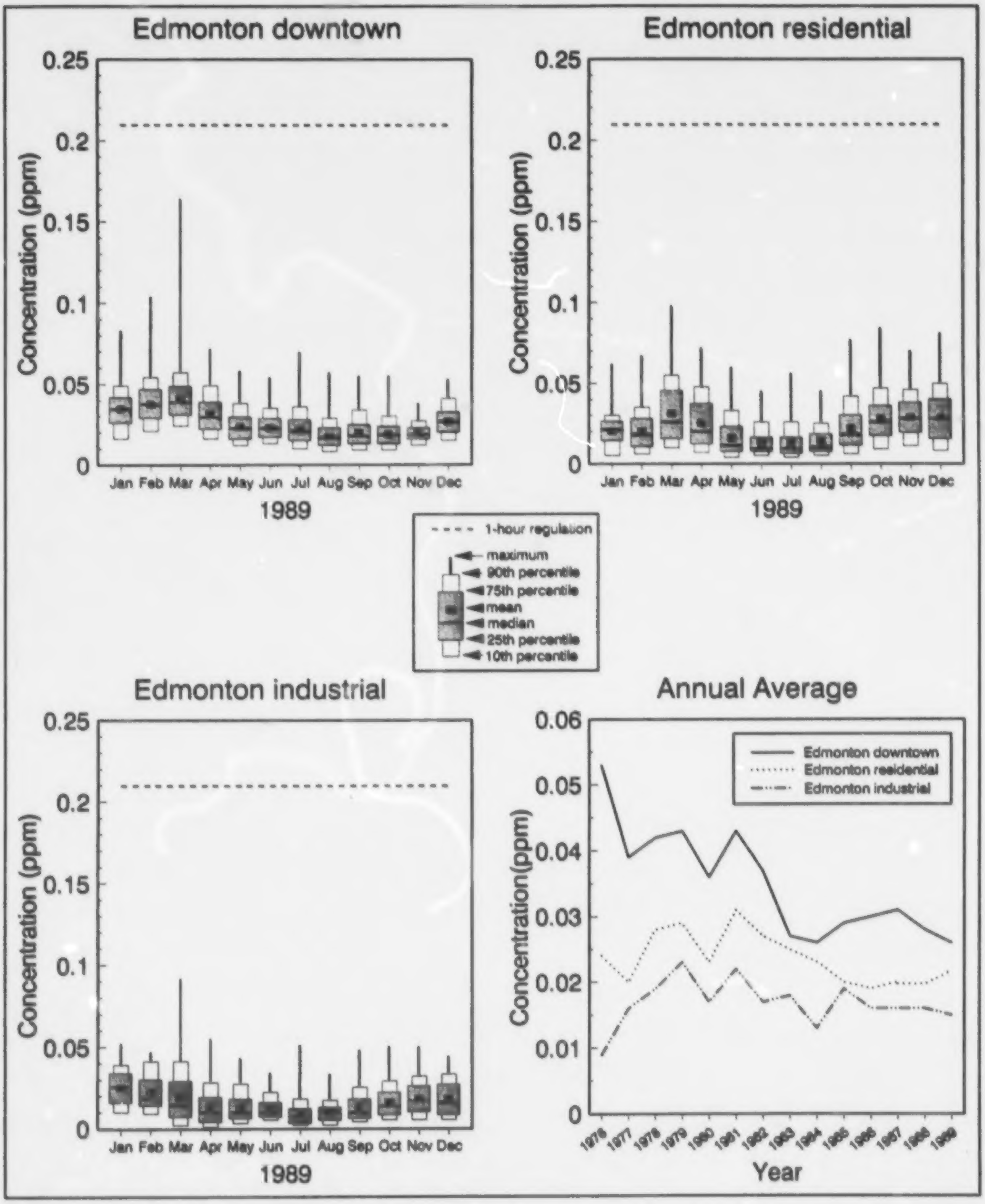

Figure 4-15 Frequency distribution of nitrogen dioxide concentrations at Edmonton.

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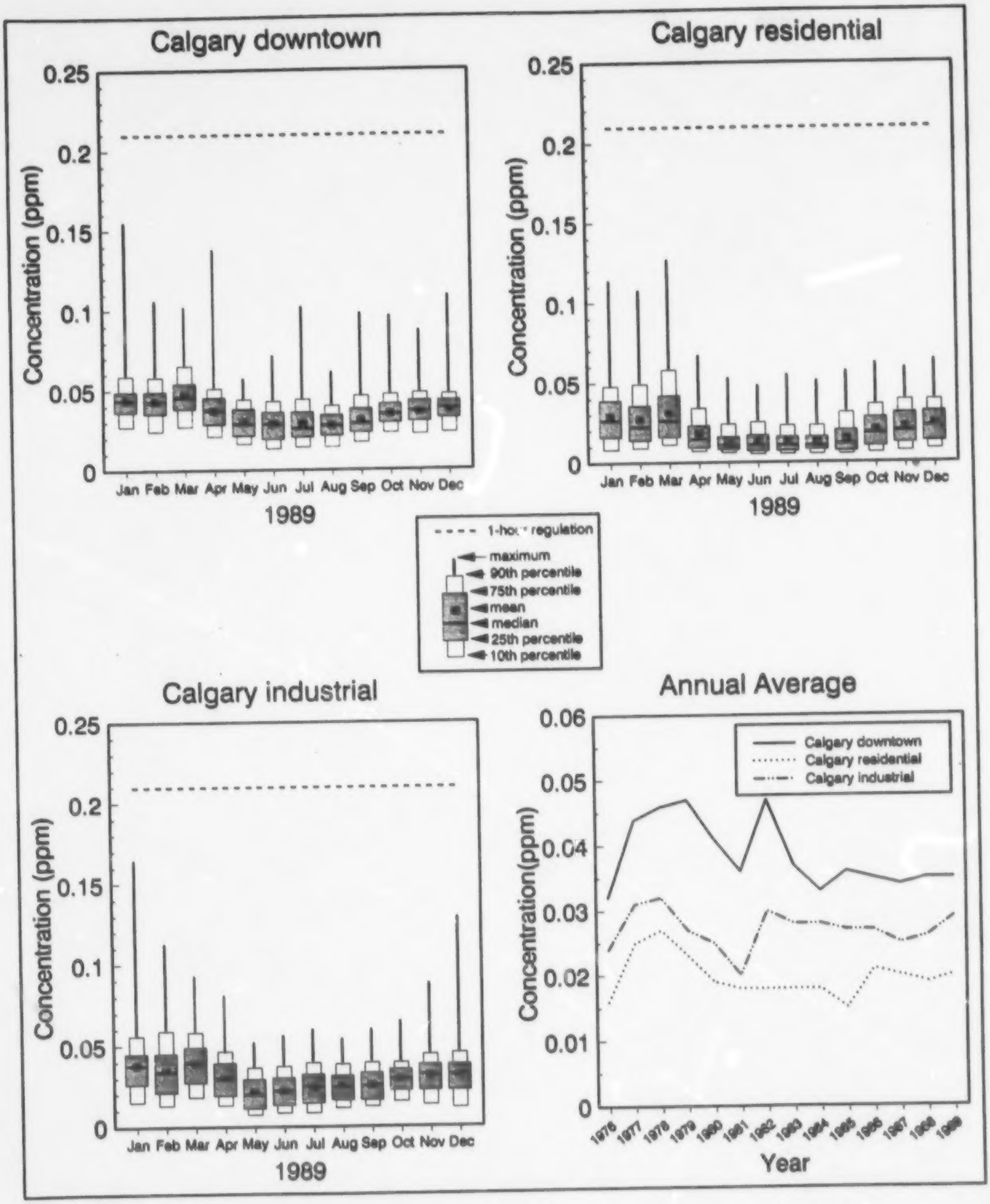

Figure 4-16 Frequency distribution of nitrogen dioxide concentrations at Calgary.

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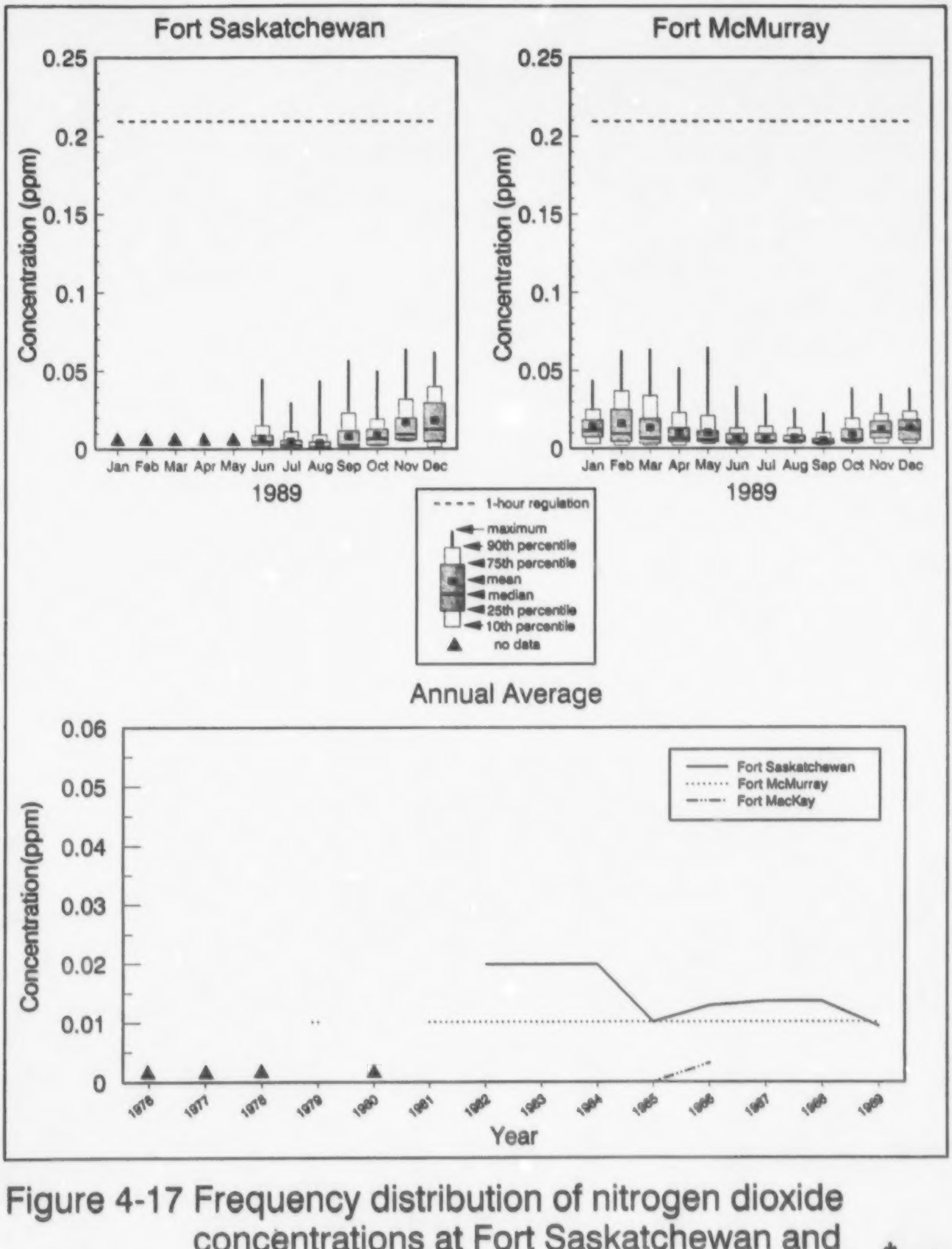

Figure 4-17 Frequency distribution of nitrogen dioxide concentrations at Fort Saskatchewan and Fort McMurray.

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NO_2 concentrations were substantially greater during the winter season at all locations than during the other seasons of the year. In the winter season, persistent temperature inversions will retard the dispersion of pollutants and therefore, lead to higher pollutant concentrations. Heating fuel consumption and automobile emissions also tend to be the highest during the winter season.

A distinct diurnal trend in NO_2 concentrations was evident at the Calgary and Edmonton urban locations. NO_2 values tended to be at a minimum in the early morning hours. An increase in NO_2 concentrations was evident in the morning rush hour and again in the afternoon rush hour. Concentrations begin to drop again at about midnight. This diurnal trend is especially prevalent during the winter months. A diurnal trend is not apparent at more rural locations such as Fort Saskatchewan and Fort McMurray where vehicular emissions are substantially lower. A trend in annual average NO_2 concentrations is not detectable at Calgary, Fort Saskatchewan or Fort McMurray monitoring stations.

4.7.4.1 *Edmonton*

The 1-hour, 24-hour and annual average ambient regulations for NO_2 were not exceeded at any of the Edmonton monitoring locations. Peak 1- and 24-hour average NO_2 concentrations of 0.164 and 0.062 ppm were recorded in March at the Edmonton downtown monitoring station. Maximum 1-hour, 24-hour and annual average NO_2 concentrations were 78%, 56% and 87% of the ambient air quality regulations, respectively. Annual average NO_2 concentrations show a significant downward trend at the Edmonton downtown monitoring station.

4.7.4.2 *Calgary*

The 1- and 24-hour average regulations for NO_2 were not exceeded at any of the Calgary monitoring locations. However, the annual average regulation of 0.030 ppm was exceeded at the Calgary downtown monitoring unit. A value of 0.035 ppm was recorded at this location. The maximum 1- and 24-hour average concentrations of 0.165 and 0.075 ppm, respectively, were measured at the Calgary industrial monitoring location. These values are 79% and 68% of the ambient air quality regulations, respectively.

4.7.4.3 *Fort Saskatchewan*

Maximum 1-hour, 24-hour and annual average air quality concentrations recorded in 1989 were 0.064, 0.043 and 0.009 ppm, respectively. These values are 30%, 39% and 30% of the ambient air quality regulations for NO_2, respectively.

4.7.1.4 *Fort McMurray*

The ambient air quality regulations for NO_2 were not exceeded at the Fort McMurray monitoring unit in 1989. Maximum 1-hour, 24-hour and annual average values were 0.065, 0.036 and 0.010 ppm, respectively. These concentrations are 31%, 33% and 33% of the 1-hour, 24-hour and annual average regulations for NO_2, respectively.

4.8 OZONE (O_3)

4.8.1 *Characteristics*

At normal ambient concentrations, O_3 is a colourless, odourless gas. However, O_3 does have a characteristics sharp odour when at very high concentrations (i.e., electrical discharges associated with arcing electric motors and lightning storms). Unlike many other pollutants, O_3 is not emitted into the atmosphere directly by man's activities, but is produced through the inter-reaction of other atmospheric constituents. In the upper atmosphere, O_3 is a naturally-occurring compound; in the lower atmosphere, O_3 is the primary end-product of photochemical reactions involving oxides of nitrogen and reactive hydrocarbons (vapours from automobile exhaust, paints, inks, solvents and gasoline) with ultra-violet light from the sun. O_3 is formed through the dissociation of NO_2 by sunlight to yield an oxygen atom, which may react with molecular oxygen to form an O_3 molecule.

The highest levels of O_3 generally occur during the spring and summer months. In the summer, the hours of sunlight are longer and stagnant meteorological conditions can cause reactive pollutants to remain in an area for several days. Occasionally, meteorological conditions can result in stratospheric O_3 being brought down to ground levels, a phenomenon known as tropopause folding. The accumulation of ozone precursors such as NO_x and hydrocarbons during the winter may also lead to elevated spring O_3 concentrations.

O_3 concentrations tend to be lower in urban locations than rural locations. Cities act as sinks, destroying O_3 that is formed near the city. In urban areas, NO emitted from motor vehicles reacts with O_3 to produce NO_2 and molecular oxygen. By contrast, in rural areas with less vehicles, O_3 (produced by the reaction of NO_x with natural hydrocarbons or from tropopause folding) is less prone to destruction by NO.

4.8.2 *Method of Monitoring*

O_3 is continuously monitored by either the chemiluminescence or ultra-violet photometry process. The chemiluminescence process involves the reacting of an air sample with ethylene. The reaction of ethylene and O_3 produces light. The intensity of the light produced is proportional to the O_3 concentration. The ultra-violet photometry process uses a mercury vapour lamp as a source of ultra-violet radiation. This method determines the O_3 concentration by the amount of ultra-violet radiation that is absorbed by the O_3 in the sample.

4.8.3 *Regulations and Guidelines*

The regulations governing the maximum permissible concentration of O_3 are based on the prevention of human health effects and effects to vegetation. Alberta has high natural levels of O_3 and frequently, especially in rural locations, exceeds the 24-hour regulation (Angle and Sandhu 1986). The ambient air quality regulations for O_3 in Alberta are:

- 0.08 ppm as a 1-hour average concentration; and
- 0.025 ppm as a 24-hour average concentration.

4.8.4 *Results*

Ambient concentrations of O_3 were monitored at all three Edmonton and Calgary air monitoring stations as well as Fort Saskatchewan and Fort McMurray in 1989. A frequency distribution of monthly O_3 concentrations and annual average O_3 concentrations for these locations is presented in Figures 4-18 to 4-20.

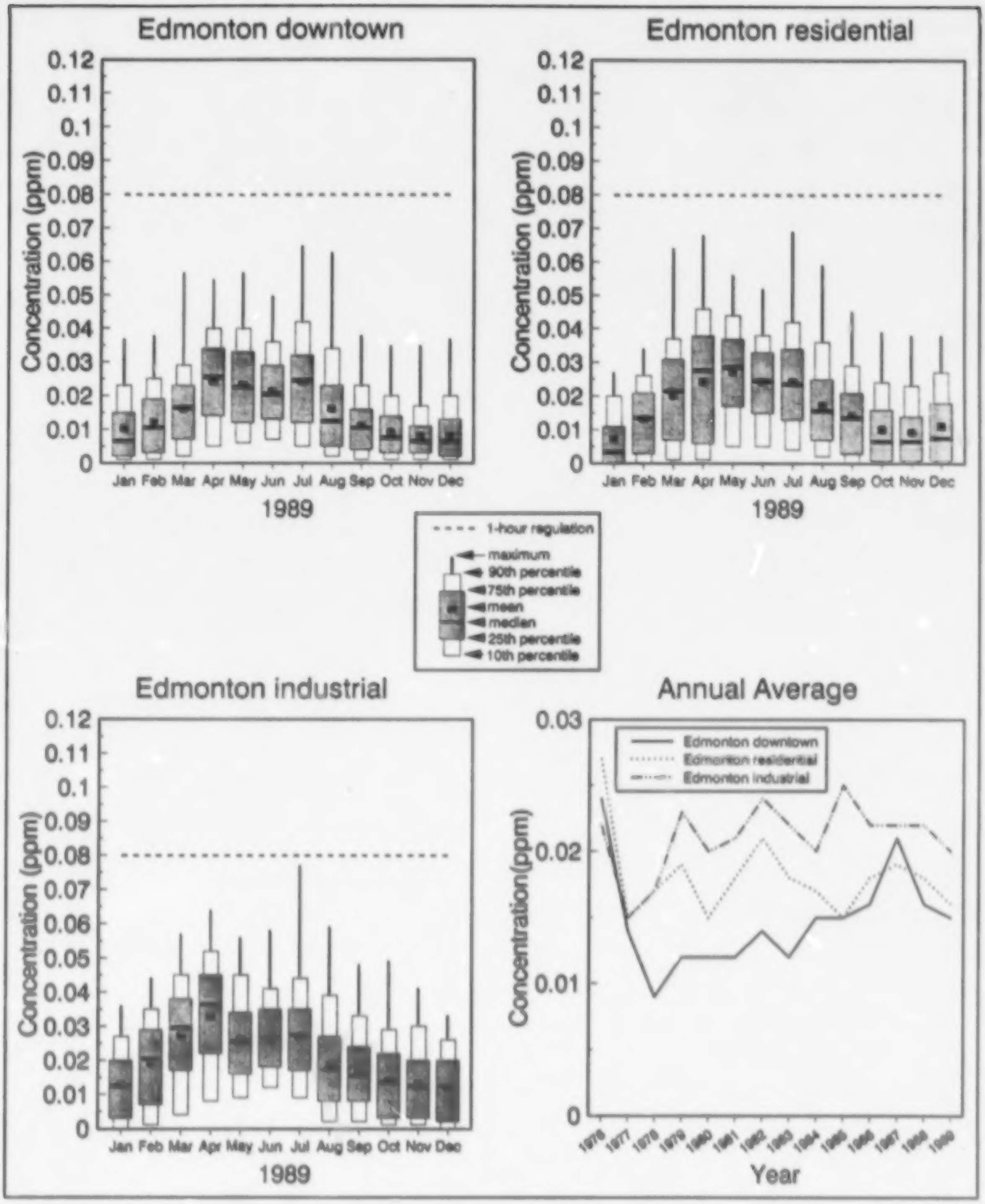

Figure 4-18 Frequency distribution of ozone concentrations at Edmonton.

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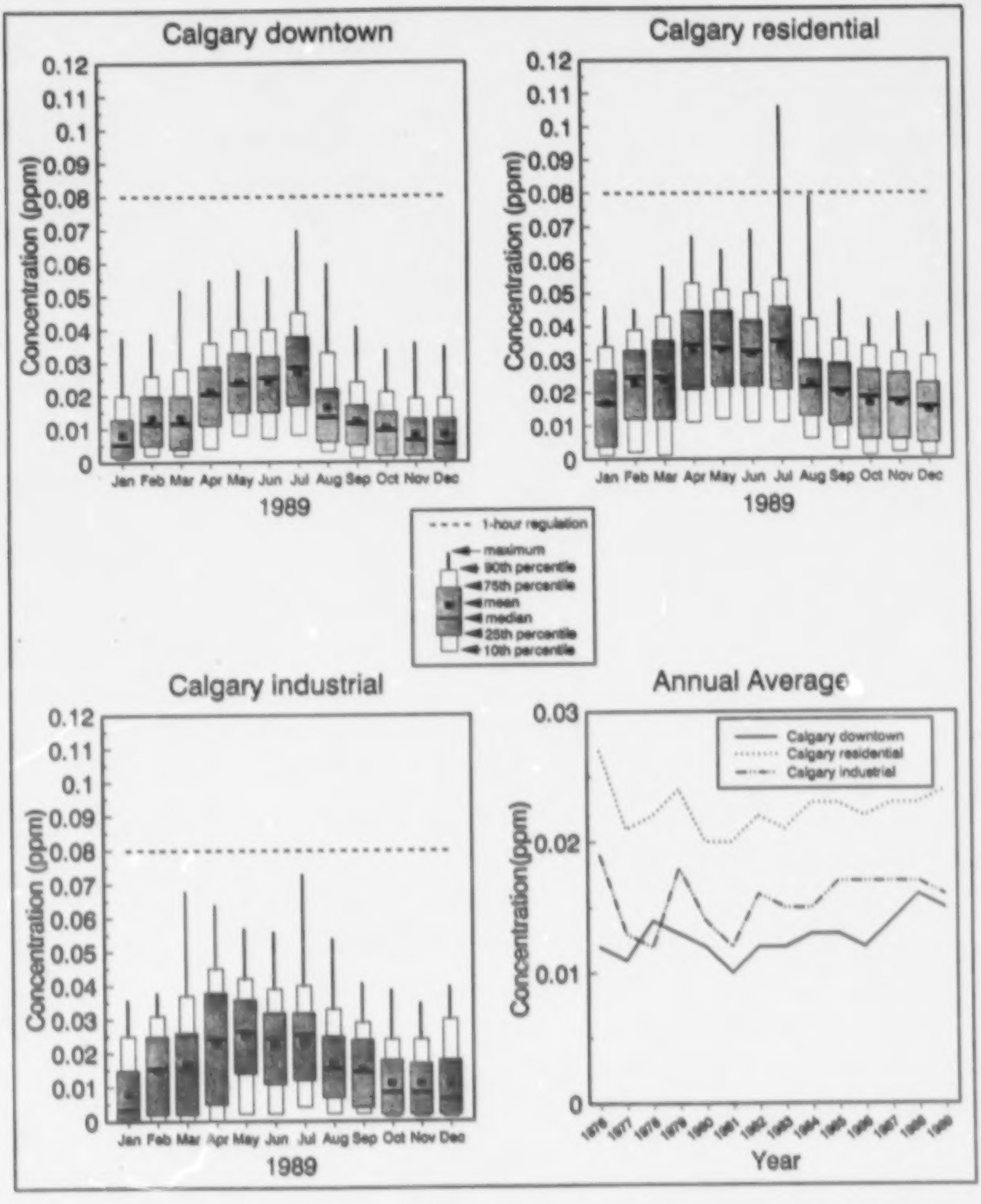

Figure 4-19 Frequency distribution of ozone concentrations at Calgary.

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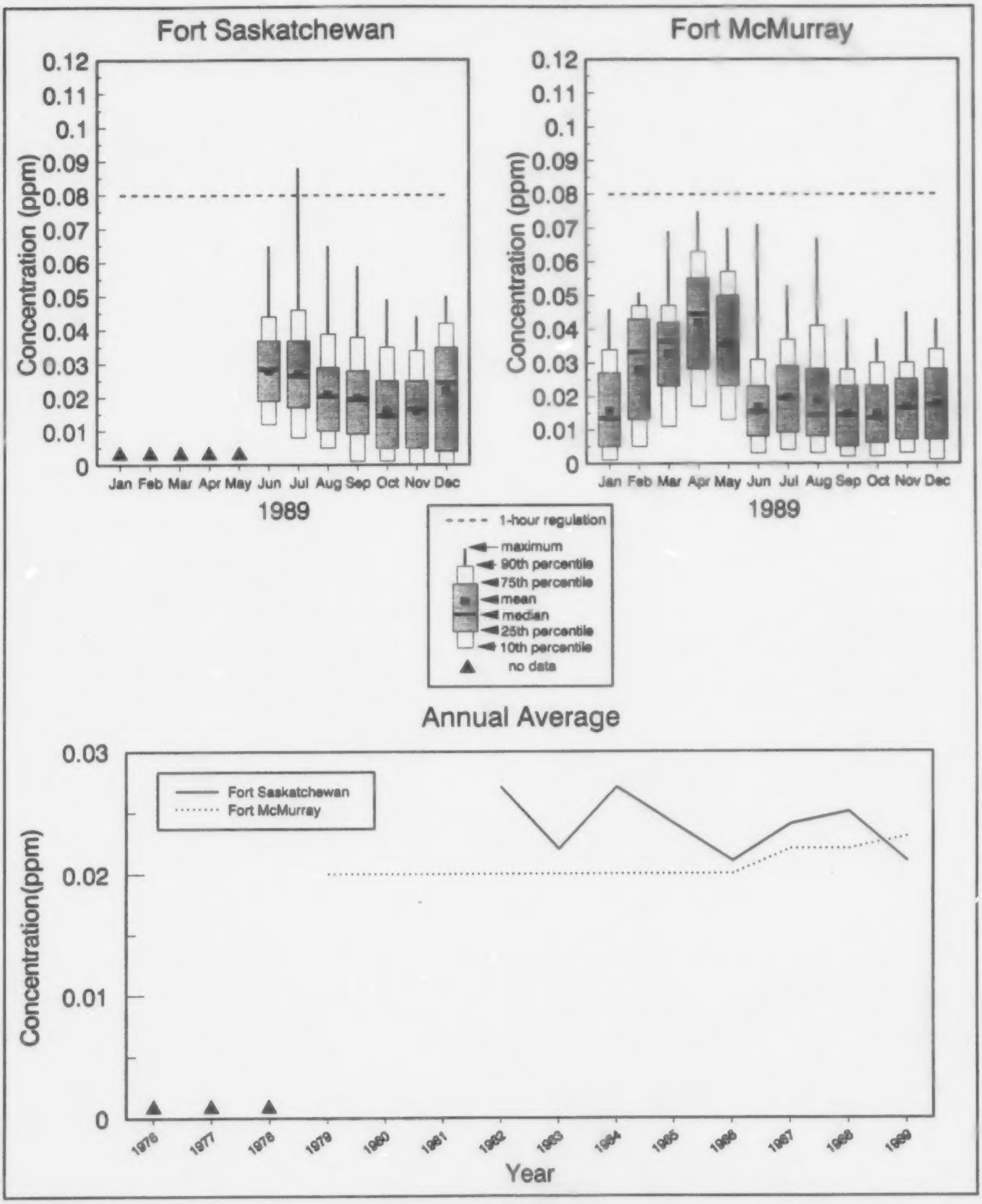

Figure 4-20 Frequency distribution of ozone concentrations at Fort McMurray and Fort Saskatchewan.

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Average O_3 concentrations reached a maximum during the spring and summer months at all monitoring stations. During the spring and summer months, O_3 production reaches a maximum due to a peak in incoming solar radiation combined with stagnant meteorological conditions which may cause reactive pollutants to remain in the region for a prolonged period of time. Transport of rural background O_3 to urban locations is also a common cause of high O_3 in Edmonton and Calgary. High daily average O_3 concentrations in the spring may be due to transport of ozone from the upper atmosphere. Annual average O_3 concentrations ranged from 0.015 ppm at Calgary downtown and Edmonton downtown monitoring units to 0.024 ppm at the Calgary residential monitoring unit. Relatively high annual average O_3 concentrations of 0.021 and 0.022 ppm were recorded at Fort Saskatchewan and Fort McMurray monitoring locations, respectively. Lower O_3 concentrations in downtown Edmonton and Calgary are likely due to higher concentrations of NO from motor vehicle emissions which act as a mechanism for O_3 destruction.

A noticeable trend towards higher O_3 concentrations in the afternoon was evident at all monitoring locations. O_3 concentrations tended to increase to a maximum in late afternoon and then drop off to a minimum in the early morning hours. The afternoon peak in O_3 is due to a corresponding peak in incoming solar radiation.

4.8.4.1 Edmonton

The ambient 1-hour average regulation of 0.080 ppm for O_3 was not exceeded at any of the Edmonton monitoring locations in 1989. A peak 1-hour average O_3 concentration of 0.077 ppm was observed in July at the Edmonton industrial monitoring station. This is 96% of the ambient 1-hour regulation for O_3.

The 24-hour average regulation for O_3 of 0.025 ppm was exceeded on numerous occasions at all Edmonton monitoring locations. The 24-hour regulation was exceeded on 112 days at the Edmonton industrial monitoring station, 63 days at the residential monitoring station and 46 days at the downtown monitoring station. The highest frequency of exceedances occurred in the month of April at the Edmonton industrial monitoring unit when 85% of days exceeded the 24-hour regulation for O_3. At the Edmonton residential and downtown monitoring locations the maximum number of exceedances were observed during May when 61% and 42% of days exceeded the 24-hour regulation, respectively. No significant trends in historical ozone concentrations were detectable at the Edmonton air quality monitoring stations.

4.8.4.2 Calgary

The 1-hour average regulation for O_3 was exceeded on four occasions during the month of July at the Calgary residential monitoring location. A peak 1-hour average O_3 concentration of 0.106 ppm was observed at this location in July.

Exceedances of the 24-hour regulation for O_3 were most frequent at the Calgary residential monitoring location. The 24-hour regulation was exceeded on 153 days at the Calgary residential monitoring station, 60 days at the industrial monitoring station and 46 days at the industrial monitoring station. Over 80% of days during the months of April through July exceeded the 24-hour regulation at the Calgary residential monitoring station. At the Calgary downtown and industrial monitoring units, the maximum number of exceedances were observed in July when the 24-hour regulation was exceeded on 71% and 35% of days, respectively. A slight upward trend in O_3 concentration was indicated at the Calgary downtown monitoring station.

4.8.4.3 Fort Saskatchewan

The 1-hour average regulation for O_3 was exceeded on one occasion at the Fort Saskatchewan monitoring station in July. A maximum 1-hour average value of 0.088 ppm was recorded. The 24-hour regulation was exceeded on 71 days at Fort Saskatchewan. The maximum number of exceedances were observed in June when 74% of the days recorded 24-hour averages greater than the ambient regulation of 0.025 ppm. It is important to note that air quality data is only available from June to December at Fort Saskatchewan. No significant trend in annual average O_3 concentrations was noted at the Fort Saskatchewan monitoring unit.

4.8.4.4 Fort McMurray

The 1-hour regulation for O_3 was not exceeded at the Fort McMurray monitoring unit. A maximum 1-hour average of 0.075 ppm was recorded in April at Fort McMurray. The 24-hour average regulation for O_3 was exceeded on 118 occasions at Fort McMurray. Exceedances of the 24-hour regulation were recorded 100% of the time in April. There is a substantial decrease in the frequency of exceedances of the 24-hour regulation in the autumn and winter months at Fort McMurray. A slight increase in annual average O_3 concentrations is evident at the Fort McMurray monitoring station.

4.9 SULPHUR DIOXIDE (SO_2)

4.9.1 Characteristics

SO_2 is a heavy, colourless gas with a pungent odour and is designated as a major atmospheric pollutant on a global basis. Processes such as the combustion of fossil fuels, smelting and roasting of sulphur-containing ores, kraft and sulphite wood pulping, and sour gas processing produce most of the anthropogenic SO_2 pollution.

In Alberta, during 1988 an estimated 626 kilotonnes of SO_2 were emitted into the atmosphere from man-made sources. About 38% of the SO_2 emissions was contributed by sulphur extraction gas plants; oil sands plants and coal-fired power plants contributed about 29% and 16%, respectively. The remaining 15% was emitted from sources such as gas plant flares, oil refineries, pulp and paper mills and fertilizer plants (Energy Resources Conservation Board, Alberta Energy and Alberta Environment 1990).

4.9.2 Method of Monitoring

SO_2 is monitored continuously by pulsed fluorescence. In this method, air is drawn through a sample chamber where it is irradiated with pulses of ultra-violet light. Any SO_2 in the sample is excited to a higher energy level and upon returning to its original state, light or fluorescence is released. The amount of fluorescence measured is proportional to the SO_2 concentration.

4.9.3 *Regulations and Guidelines*

The regulations governing the maximum permissible concentration of SO_2 are based on preventing damage to vegetation. At these levels, no known health effects are detectable. In regulating SO_2, Alberta has adopted Environment Canada's most rigorous ambient regulation:

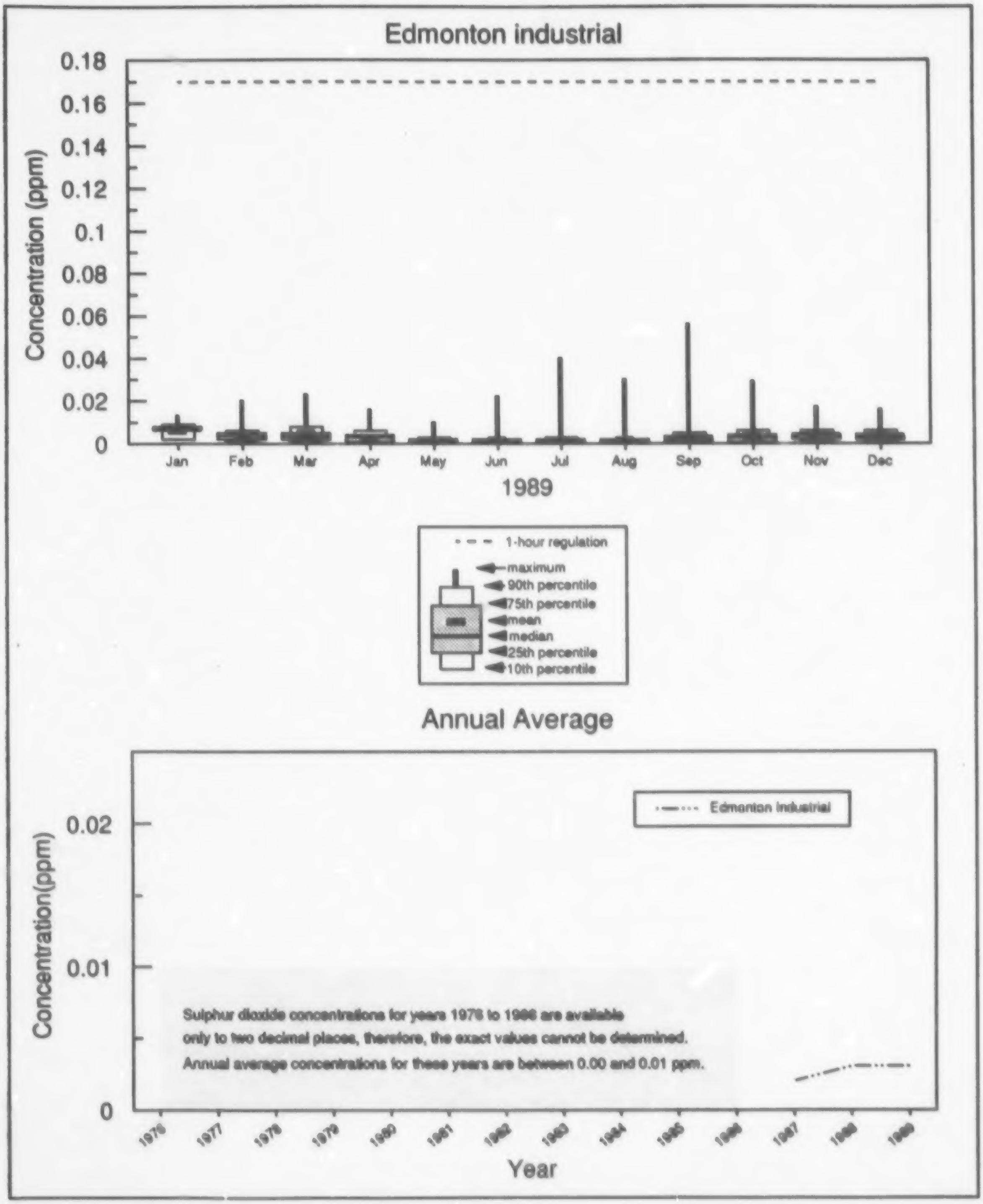
- 0.17 ppm as a 1-hour average concentration;
- 0.06 ppm as a 24-hour average concentration; and
- 0.01 ppm as an annual arithmetic concentration.

4.9.4 *Results*

SO_2 was monitored on a continuous basis at Edmonton and Calgary industrial locations, Fort Saskatchewan, Fort McMurray and Fort MacKay. Figures 4-21 to 4-23 show monthly frequency distributions and annual averages of SO_2 at these monitoring locations. Annual average SO_2 concentrations ranged from 0.002 ppm at Fort Saskatchewan to 0.004 ppm at Fort McMurray in 1989. These values are substantially lower than the standard of 0.010 ppm as an annual average for SO_2. SO_2 concentrations tend to be greater during the winter months due to meteorological conditions such as persistent inversions which do not allow pollutants to disperse rapidly. A tendency for SO_2 concentrations to increase during daylight hours and decrease at night is apparent at most monitoring locations. This diurnal trend is most prevalent at the Calgary industrial, Fort McMurray and Fort MacKay monitoring locations. Annual average SO_2 concentrations are not high enough to resolve a significant trend.

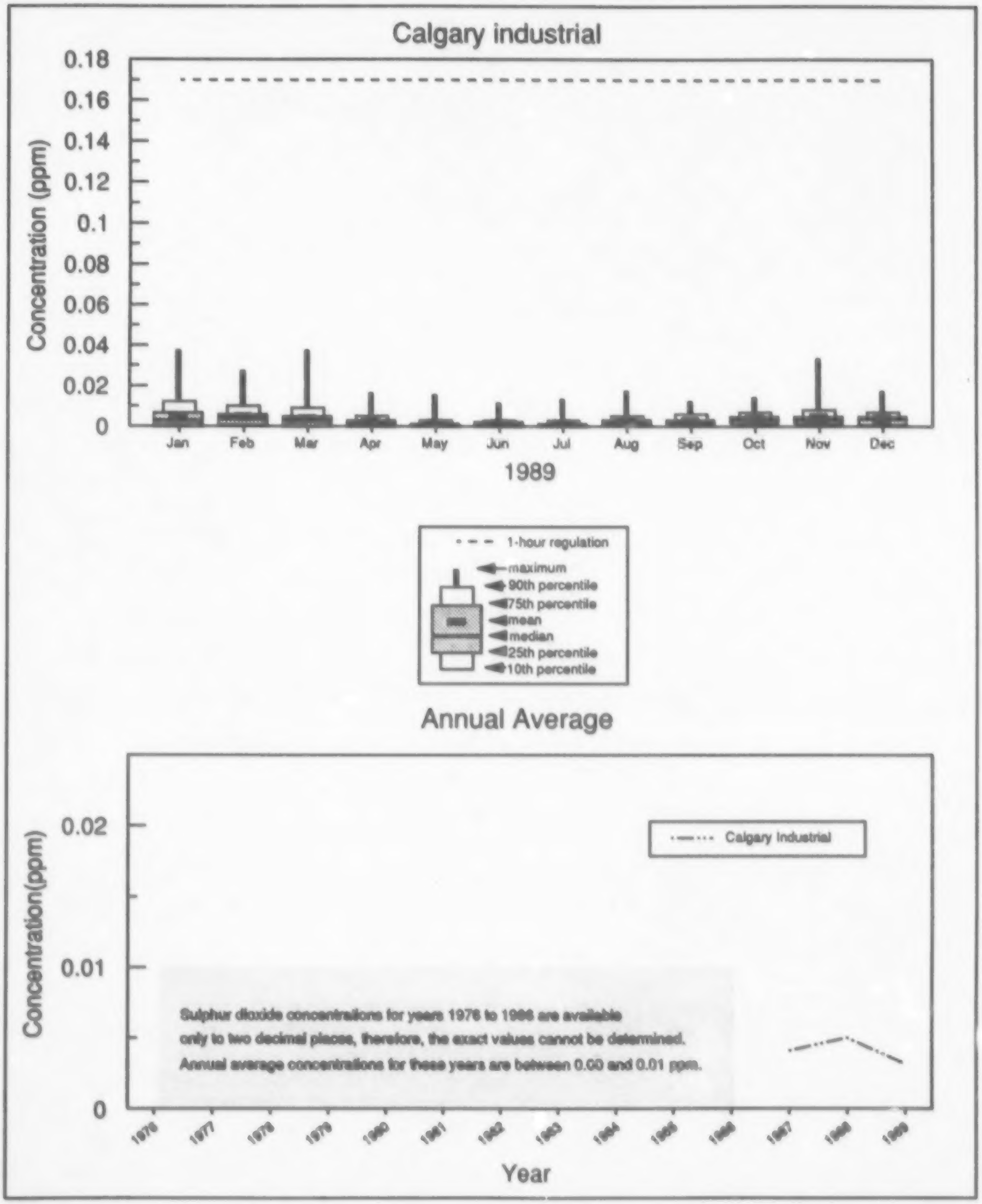
4.9.4.1 *Edmonton*

The 1-hour, 24-hour and annual average SO_2 regulations were not exceeded at the Edmonton industrial monitoring location. The peak 1- and 24-hour average SO_2 concentrations observed in 1989 were 0.056 ppm and 0.012 ppm, respectively. These values are 33% and 20% of the 1- and 24-hour regulations, respectively.



Sulphur dioxide concentrations for years 1976 to 1986 are available
only to two decimal places, therefore, the exact values cannot be determined.
Annual average concentrations for these years are between 0.00 and 0.01 ppm.

Figure 4-21 Frequency distribution of sulphur dioxide concentrations at Edmonton.



Sulphur dioxide concentrations for years 1976 to 1986 are available only to two decimal places, therefore, the exact values cannot be determined. Annual average concentrations for these years are between 0.00 and 0.01 ppm.

Figure 4-22 Frequency distribution of sulphur dioxide concentrations at Calgary.

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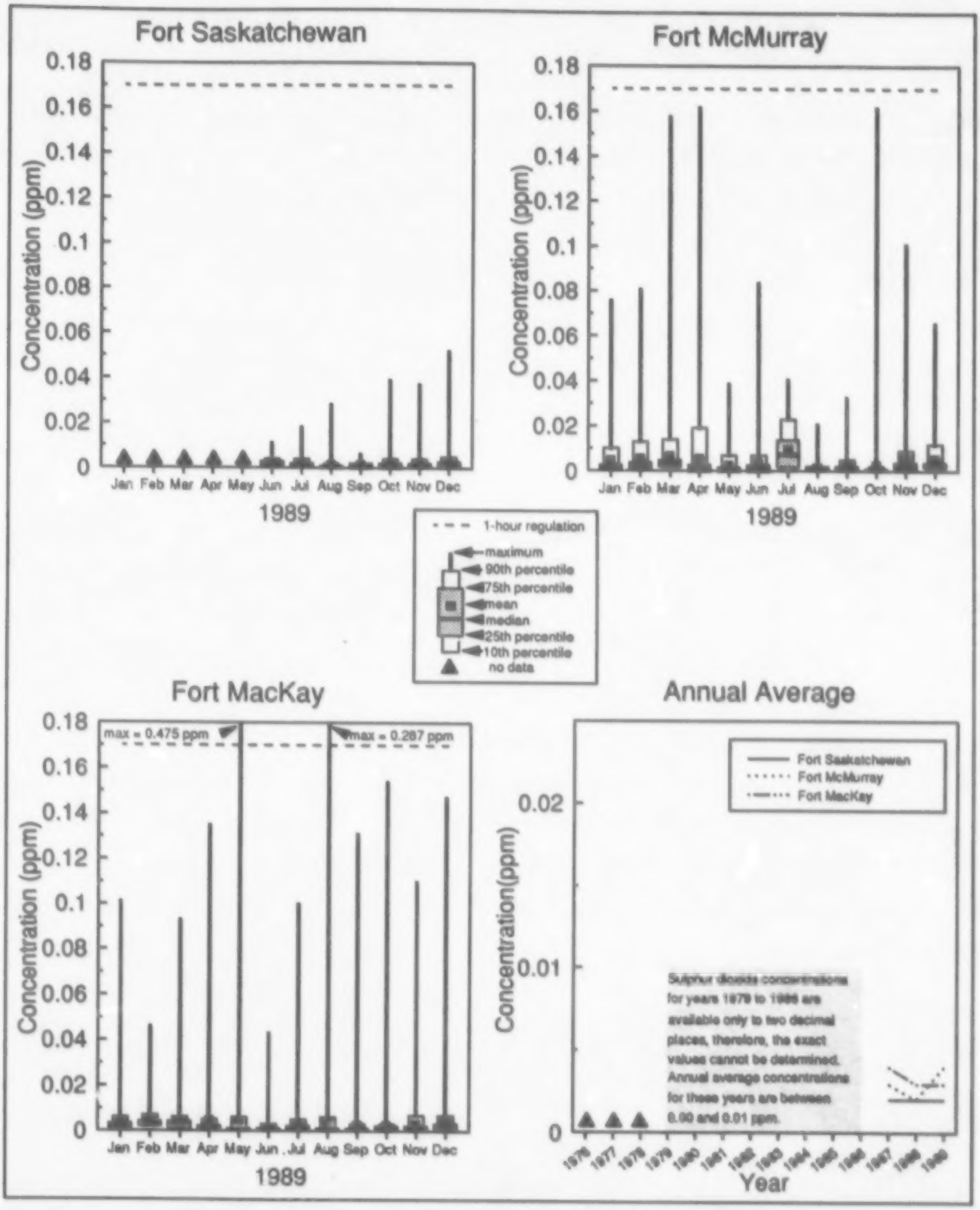

Sulphur dioxide concentrations for years 1979 to 1986 are available only to two decimal places, therefore, the exact values cannot be determined. Annual average concentrations for these years are between 0.00 and 0.01 ppm.

Figure 4-23 Frequency distribution of sulphur dioxide concentrations at Fort Saskatchewan, Fort McMurray and Fort MacKay.

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4.9.4.2 *Calgary*

The maximum observed 1- and 24-hour average SO_2 concentrations at the Calgary industrial monitoring station in 1989 were 0.037 and 0.020 ppm, respectively. These values are 22% and 33% of the 1- and 24-hour average regulations for SO_2, respectively.

4.9.4.3 *Fort Saskatchewan*

Regulations for SO_2 were not exceeded at the Fort Saskatchewan monitoring unit in 1989. Maximum 1- and 24-hour average SO_2 concentrations were 0.052 and 0.011 ppm, respectively. These values are 31% and 18% of the 1- and 24-hour standards for SO_2, respectively.

4.9.4.4 *Fort McMurray and Fort MacKay*

The regulations for SO_2 were not exceeded at the Fort McMurray monitoring unit. Maximum 1- and 24-hour average SO_2 concentrations recorded at this location were 0.162 and 0.039 ppm, respectively. These values are 95% and 65% of the 1- and 24-hour regulations for SO_2, respectively.

Exceedances of the 1-hour average regulation were recorded in May and August at the Fort MacKay monitoring unit. Maximum 1-hour average SO_2 concentrations during these months were 0.475 and 0.287 ppm, respectively. A total of five hours exceeded the regulation in May while two hours exceeded the regulation in August. Winds during these exceedance episodes were from the south to southeast, which suggest, that the source of SO_2 exceedances was from the oil sands processing area. Annual average and 24-hour average SO_2 concentrations did not exceed the regulations at Fort MacKay in 1989.

4.10 TOTAL HYDROCARBONS (THC)

4.10.1 Characteristics

The term "total hydrocarbons" refers to the combined concentration of two broad categories of organic compounds: reactive and non-reactive hydrocarbons. The non-reactive component is primarily methane, a colourless, odourless gas that is naturally present in the atmosphere a concentrations of about 1.5 ppm. The reactive component is essentially organic compounds other than methane that are usually present in much lower concentrations. Reactive hydrocarbons are especially important because they will react with nitrogen oxides in the presence of sunlight to form ozone.

Natural sources of hydrocarbons include trees and other vegetation, and the decay of animal and plant material. The primary man-made sources of hydrocarbons are motor vehicles, and gasoline marketing and storage tanks. Smaller amounts of hydrocarbons are emitted by sources such as the petroleum and chemical industries, drycleaning, fireplaces, natural gas combustion and aircraft traffic. Motor vehicle emissions of hydrocarbons are the result of inefficient combustion.

4.10.2 Method of Monitoring

Hydrocarbons are monitored continuously by a hydrogen flame ionization detector. When burned, carbon-hydrogen bonds break creating ions that conduct an electric current. This current is then measured by an electrometer to give a signal proportional to the number of ions.

4.10.3 Regulations and Guidelines

Alberta currently has no ambient air quality regulations for hydrocarbons.

4.10.4 Results

Hydrocarbons were monitored at all Alberta Environment continuous air quality stations in 1989. Frequency distributions of these values are illustrated in Figures 4-24 to 4-26. These figures also show annual average THC concentrations. Annual average THC concentrations ranged from 1.8 to 2.3 ppm. The lowest annual average concentrations were

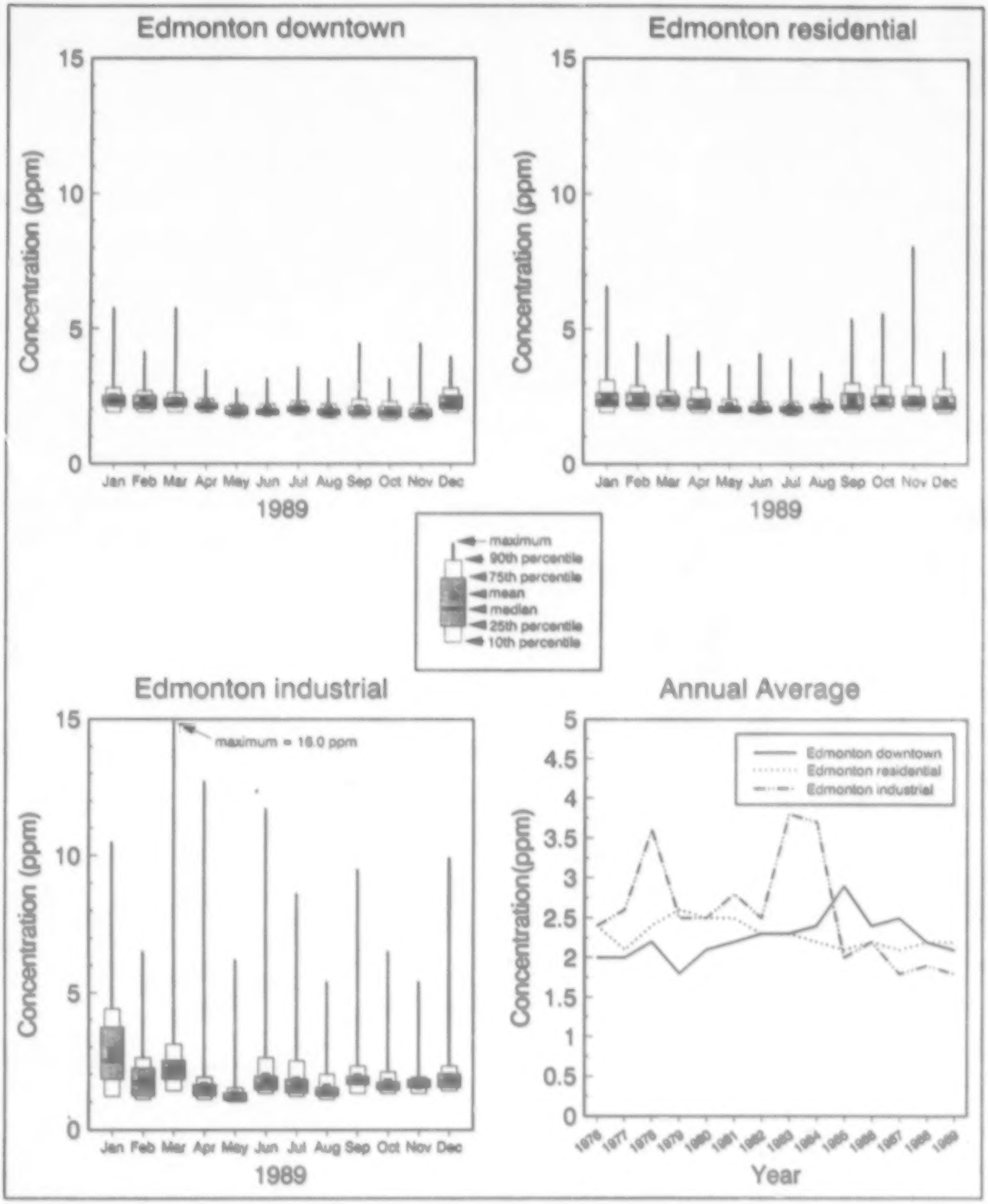

Figure 4-24 Frequency distribution of total hydrocarbon concentrations at Edmonton.

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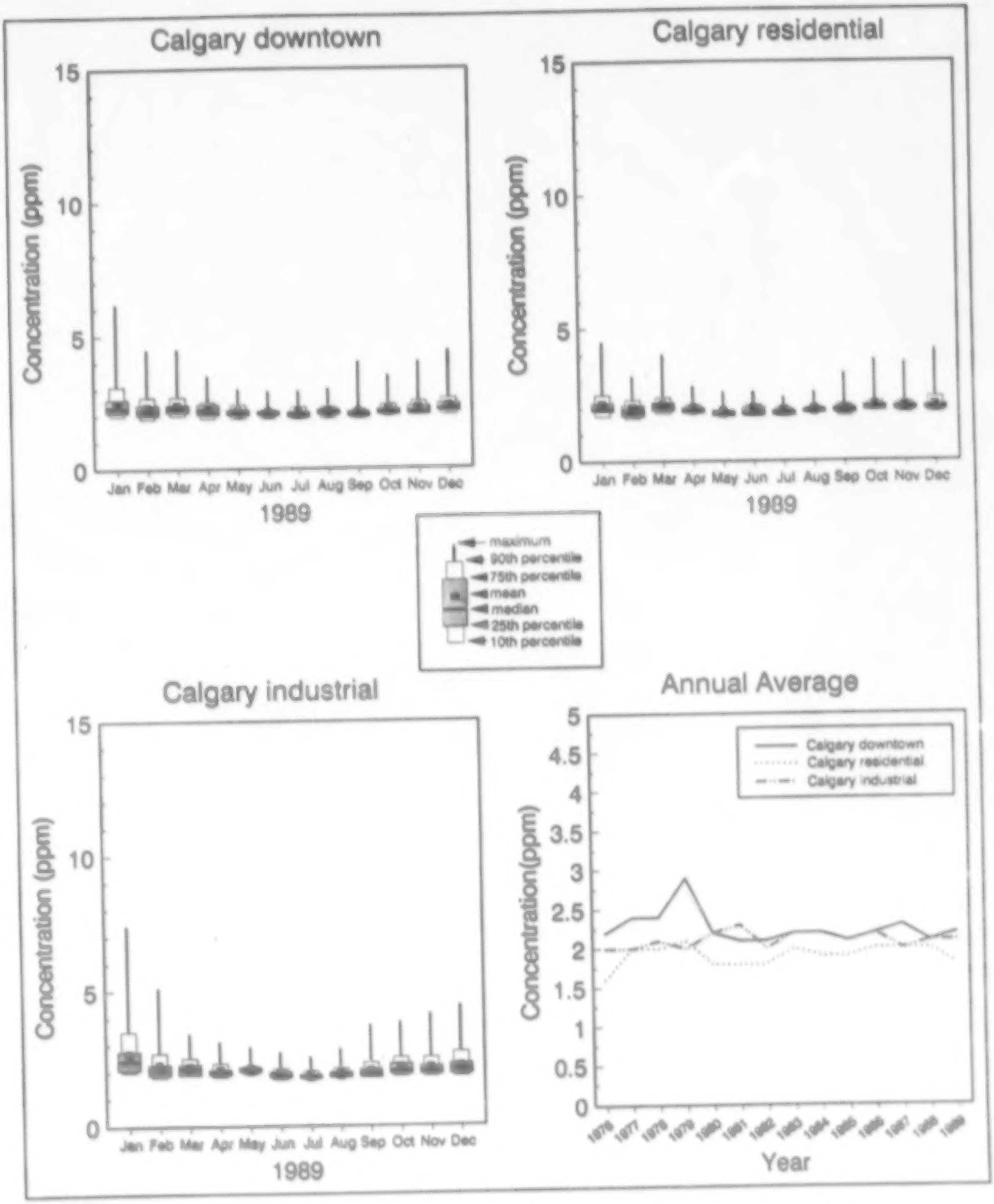

Figure 4-25 Frequency distribution of total hydrocarbon concentrations at Calgary.

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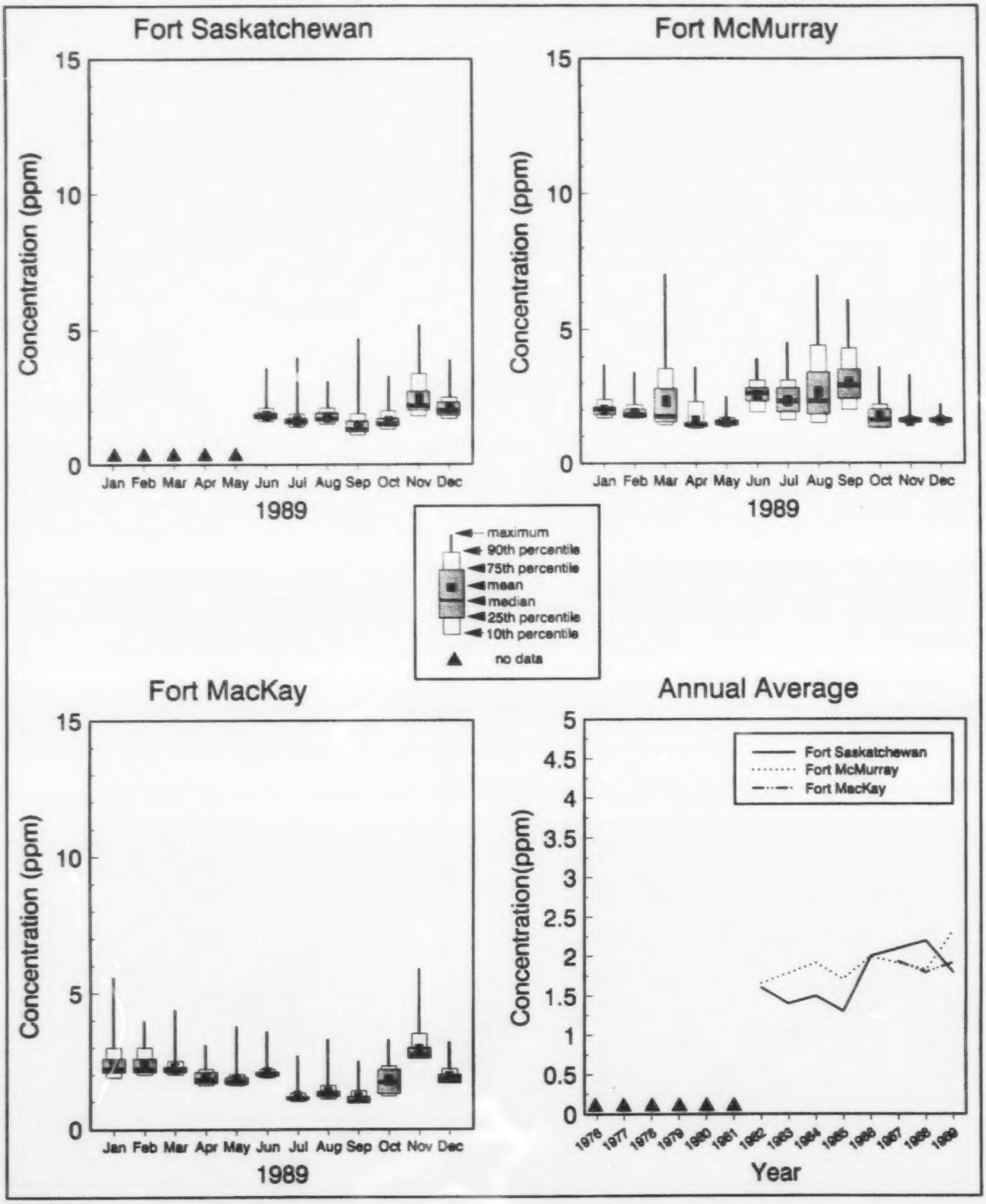

Figure 4-26 Frequency distribution of total hydrocarbon concentrations at Fort Saskatchewan, Fort McMurray and Fort MacKay.

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recorded at the Edmonton industrial, Calgary residential and Fort Saskatchewan monitoring units while the highest concentrations were monitored at the Edmonton residential and Calgary downtown monitoring locations.

Hydrocarbon concentrations were generally highest in the winter months due to an increased frequency of inversions which inhibit the dispersion of pollutants. The exception to this was Fort McMurray where the maximum THC concentrations were recorded in the spring season. At urban locations, such as Edmonton and Calgary, the predominant source of reactive hydrocarbons was automobile emissions.

Significant diurnal trends of THC were noted at air quality monitoring stations which are located within close proximity of major traffic arteries. Diurnal trends were especially evident during the winter months at the Edmonton downtown, Edmonton residential, Calgary downtown, Calgary industrial and Fort Saskatchewan monitoring stations.

4.10.4.1 *Edmonton*

Maximum 1-hour average THC concentrations ranged from 5.8 ppm at the downtown monitoring station to 16.0 ppm at the industrial monitoring location. Maximum concentrations were generally observed in the winter season with the exception of the industrial monitoring station where relatively high THC concentrations were also observed in March, April and June. Relatively high THC concentrations observed in the industrial region were likely due to fugitive emissions originating from petrochemical storage tanks and transportation vehicles. A slight decrease in annual average THC concentrations was shown at both the Edmonton downtown and industrial monitoring location.

4.10.4.2 *Calgary*

Maximum 1-hour THC concentrations ranged from 4.5 ppm at the residential monitoring unit to 7.4 ppm at the industrial monitoring unit. These values occurred in January at both monitoring stations. Maximum concentrations were recorded during the winter months at all Calgary air quality monitoring stations.

4.10.4.3 Fort Saskatchewan

The maximum 1-hour average THC concentrations observed at the Fort Saskatchewan monitoring unit was 5.2 ppm, recorded in November. Hydrocarbons were monitored only during the months of June through December at Fort Saskatchewan. Annual average THC values do not indicate a trend at Fort Saskatchewan.

4.10.4.4 Fort McMurray and Fort MacKay

The maximum observed 1-hour concentration of THC observed at the Fort McMurray monitoring unit was 7.0 ppm which occurred in August. The peak 1-hour average THC reading at Fort MacKay in 1989 was 5.9 ppm. This value was recorded in November. A trend of THC concentrations is not evident at Fort McMurray and Fort McKay.

5. INTERMITTENT MONITORING RESULTS

Data analysis has been conducted on intermittent air quality data to resolve, on a monthly basis, the maximum, minimum and mean loadings of specified parameters. A trend analysis was also performed on annual average parameter loadings using Daniel's trend test. This test is described in Section 4.

5.1 TOTAL SUSPENDED PARTICULATES (TSP)

5.1.1 Characteristics

Air pollutants are not only in the g[illegible] form. Tiny particles of solid material or liquid droplets, defined collectively as particulates, are also present in the air in great numbers, and may constitute an air pollution problem. The particles range in size from 0.001 to 500 microns (a human hair is about 100 microns in diameter) and, depending on their size and other properties, may remain suspended in the air for a few seconds or indefinitely.

In general, particles smaller than one micron in diameter originate as a by-product of condensation and combustion. Particles between 1 micron and 10 microns in diameter usually include soil, process dusts, and combustion products from industries. Particles larger than 10 microns in diameter generally result from mechanical processes such as wind erosion, grinding, spraying and vehicular activity.

Suspended particulates may result from a variety of natural and man-made sources. These include soil, road dust, dust resulting from other human activities (i.e., agriculture), smoke from forest fires, smoke from recreational sources (i.e., camp fires and fireplaces), vehicular exhaust emissions, and industrial emission sources.

5.1.2 Method of Monitoring

Suspended particulate matter is measured by the high-volume sampler. The sampler consists of a vacuum system and filter housed in a shelter and operates on the same principle as a vacuum cleaner. The TSP matter in the atmosphere is collected by drawing a known volume of air through a pre-weighed filter for a 24-hour period every sixth day according to the NAPS monitoring schedule. The filter is then reweighed to determine the mass of the particles collected.

5.1.3 *Regulations and Guidelines*

Regulations governing the maximum permissible levels of TSP are based on visibility reduction and nuisance effects. Alberta has adopted the most rigorous federal standards for maximum TSP loadings:

- 100 ug/m^3 (micrograms per cubic meter) as a 24-hour total loading; and
- 60 ug/m^3 as an annual geometric mean loading.

5.1.4 *Results*

In 1989, suspended particulates were monitored at all three Edmonton and Calgary monitoring stations, and at Fort Saskatchewan and Ellerslie monitoring locations. Mean, maximum and minimum TSP loadings are presented by month in Figures 5-1 to 5-3. Annual average loadings of TSP ranged from 20.8 ug/m^3 at Ellerslie to 68.2 ug/m^3 at the Calgary industrial monitoring location. Suspended particulate loadings were much lower at Fort Saskatchewan and Ellerslie than at the urban locations of Edmonton and Calgary.

5.1.4.1 *Edmonton*

Exceedances of the 24-hour regulation occurred at all Edmonton monitoring stations in 1989. The downtown monitoring station recorded the highest frequency of exceedances probably due to greater traffic density than the residential and industrial monitoring locations. The maximum number of exceedances was measured in April at the downtown monitoring unit when 40% of the observations exceeded the regulation of 100 ug/m^3. A peak 24-hour total TSP loading of 180.9 ug/m^3 was observed at the Edmonton industrial monitoring unit in September. The annual average regulation for TSP was not exceeded in Edmonton. A slight decrease in annual average TSP loading is indicated at all Edmonton monitoring stations.

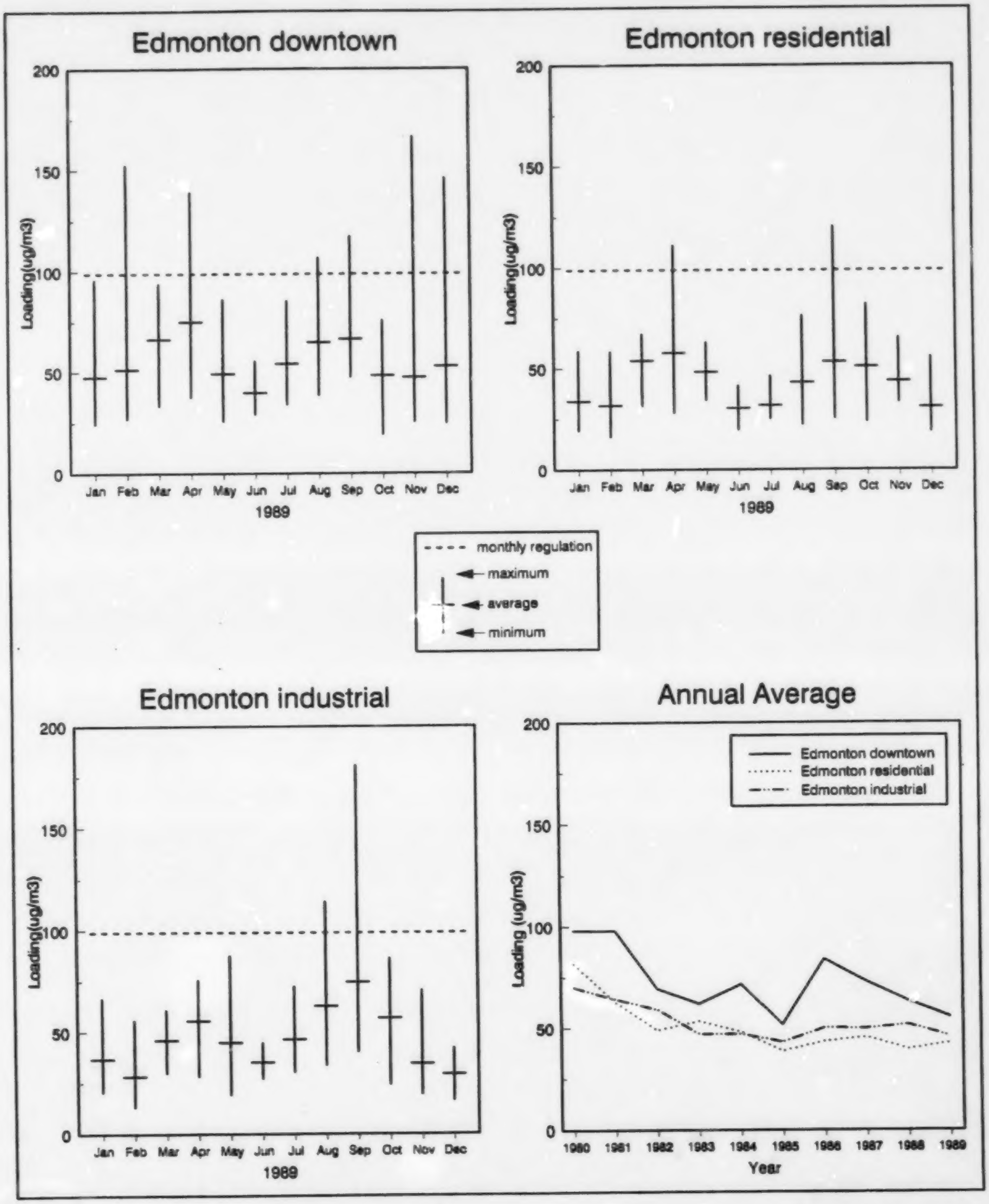

Figure 5-1 Total suspended particulate loadings at Edmonton.

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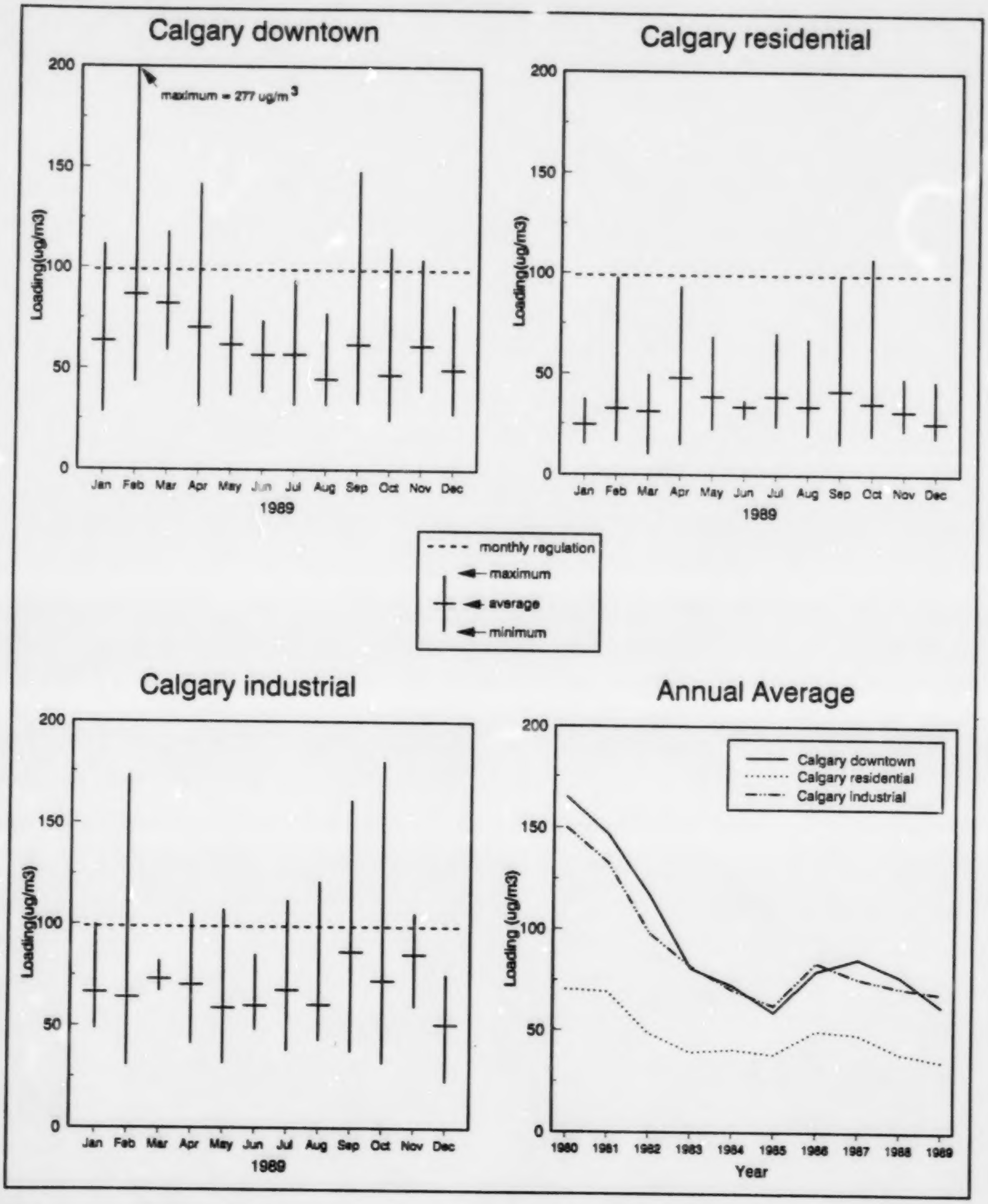

Figure 5-2 Total suspended particulate loadings at Calgary.

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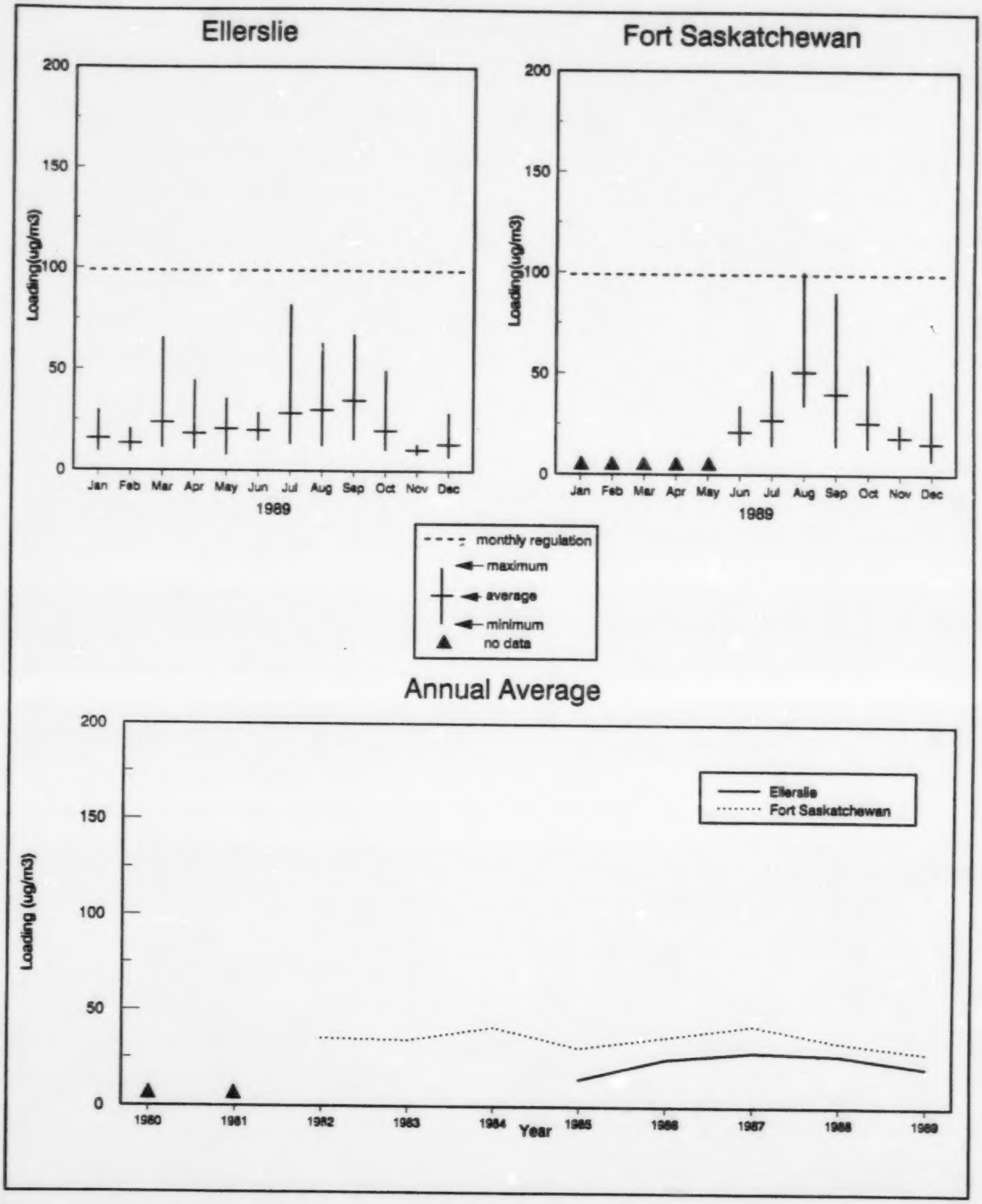

Figure 5-3 Total suspended particulate loadings at Ellerslie and Fort Saskatchewan.

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5.1.4.2 Calgary

Exceedances of the 24-hour regulation for TSP were exceeded frequently at the downtown and industrial monitoring locations. One exceedance was recorded at the residential monitoring unit. Exceedances were observed 40% of the time during January, March and April at the downtown location and during February, April and September at the industrial monitoring unit. The maximum TSP loading observed in Calgary was 276.9 ug/m^3 which occurred in February at the downtown monitoring location.

The annual average regulation for TSP was exceeded at the Calgary downtown and industrial locations. Annual average TSP loadings of 62.1 ug/m^3 and 68.2 ug/m^3 were recorded at these two locations, respectively. A significant decrease in annual average total suspended particulate loadings is evident at the Calgary downtown and industrial monitoring stations. A slight decrease is also evident at the residential monitoring station.

5.1.4.3 Fort Saskatchewan and Ellerslie

The maximum TSP loading recorded at the Fort Saskatchewn monitoring unit during 1989 (June to December) was 100.2 ug/m^3 which was measured in the month of August. This value is slightly greater than the 24-hour regulation of 100 ug/m^3 for TSP.

No exceedances of the 24-hour regulation for TSP were recorded at Ellerslie during 1989. A maximum TSP loading of 81.9 ug/m^3 was observed in July. A trend in annual average TSP loadings is not detectable at Ellerslie or Fort Saskatchewan.

5.2 BENZO (a) PYRENE (BaP)

5.2.1 Characteristics

BaP is an organic compound that belongs to a class of compounds known as polycyclic aromatic hydrocarbons (PAH). BaP is formed during the combustion of organic materials and is present in all types of soot and smoke. The prime sources are heat and power generation, refuse burning, coke production and motor vehicle emissions. BaP has also been detected in tobacco smoke, wood smoke from fireplaces and forest fires.

Most sources of BaP have not been accurately characterized because of the variety of factors that influence BaP formation. For example, during the process of combustion, the amount of excess air, combustion temperature, fuel moisture content and feed conditions will affect the formation of BaP.

5.2.2 *Method of Monitoring*

BaP loadings are obtained by chemical analysis of high-volume sampler filters. The result is a 24-hour accumulated loading of BaP expressed in micrograms per 1000 cubic meters (ug/1000 m^3).

5.2.3 *Regulations and Guidelines*

Alberta Environment does not currently have regulations or guidelines for ambient loadings of BaP.

5.2.4 *Results*

BaP was monitored at all three Edmonton and Calgary air quality monitoring stations, Fort Saskatchewan and Ellerslie monitoring units. A distinct seasonal trend in BaP loadings was apparent at all monitoring locations. Much higher loadings of BaP were evident in the winter than in the other seasons of the year. Relatively low BaP loadings were observed in the summer months at all stations. During the winter, meteorological conditions that retard the dispersion of pollutants, such as inversions and low wind speeds, tend to be more prevalent. A second contributing factor is that automobile engines run less efficiently during cold temperatures which leads to an increase in BaP emissions from automobiles.

Annual average BaP loadings ranged from 0.03 ug/1000 m^3 at Fort Saskatchewan and Ellerslie to 0.41 ug/1000 m^3 at the Calgary downtown monitoring unit. Annual average BaP loadings are much higher at monitoring stations located in the vicinity of heavily used traffic arteries. Minimum, maximum and mean BaP loadings are presented in Figures 5-4 to 5-6 for each monitoring station.

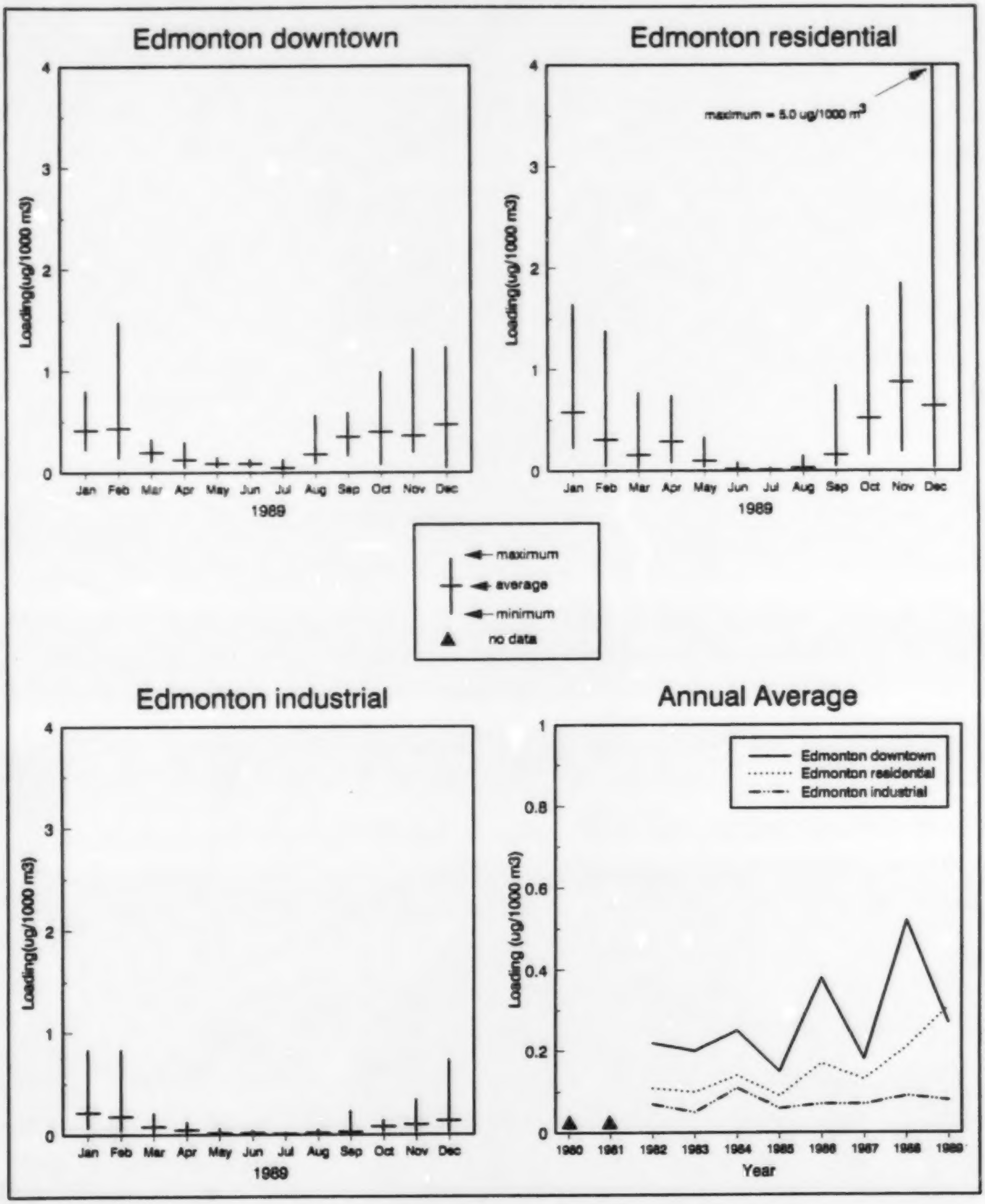

Figure 5-4 Benzo (a) Pyrene loadings at Edmonton.

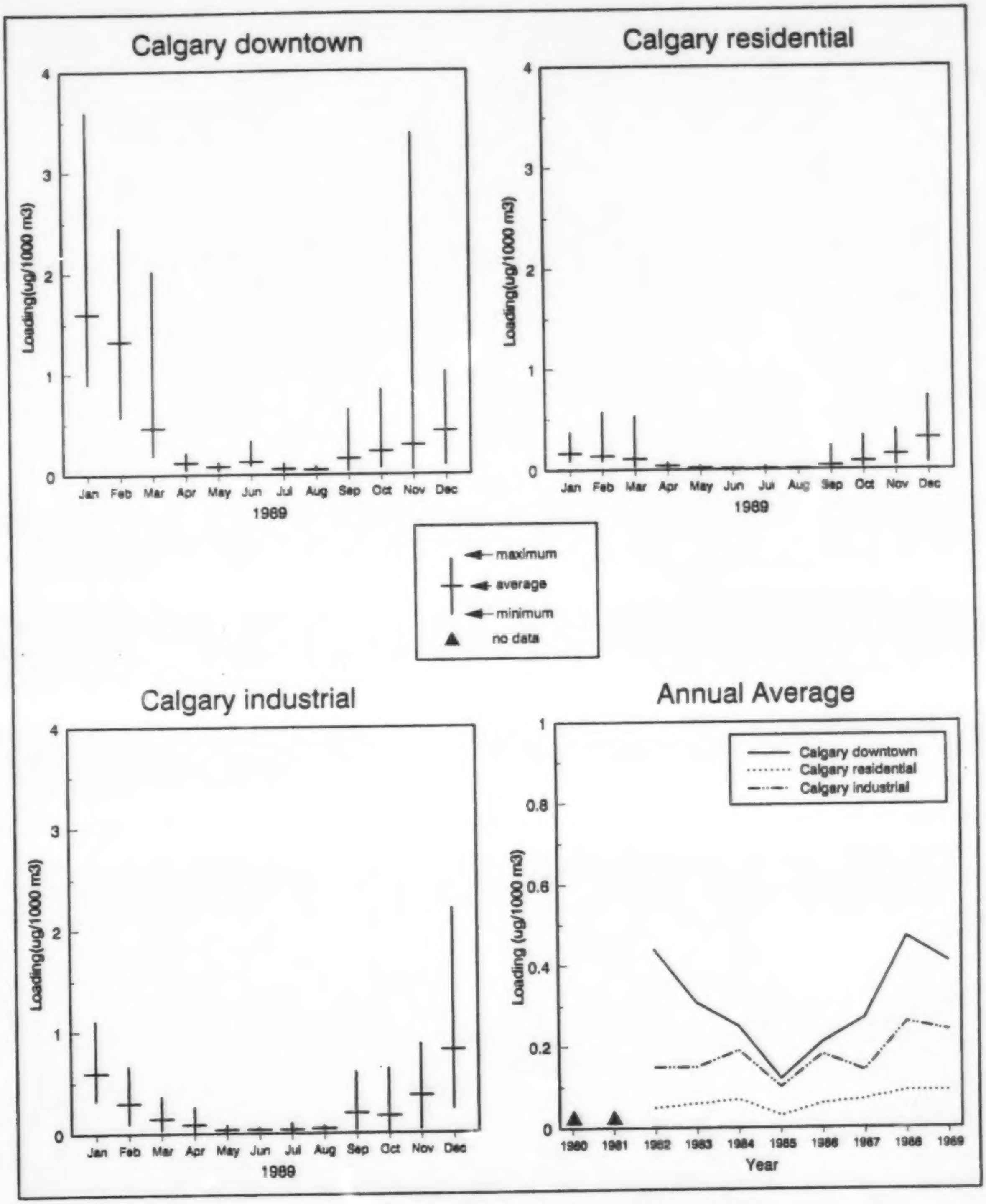

Figure 5-5 Benzo (a) Pyrene loadings at Calgary.

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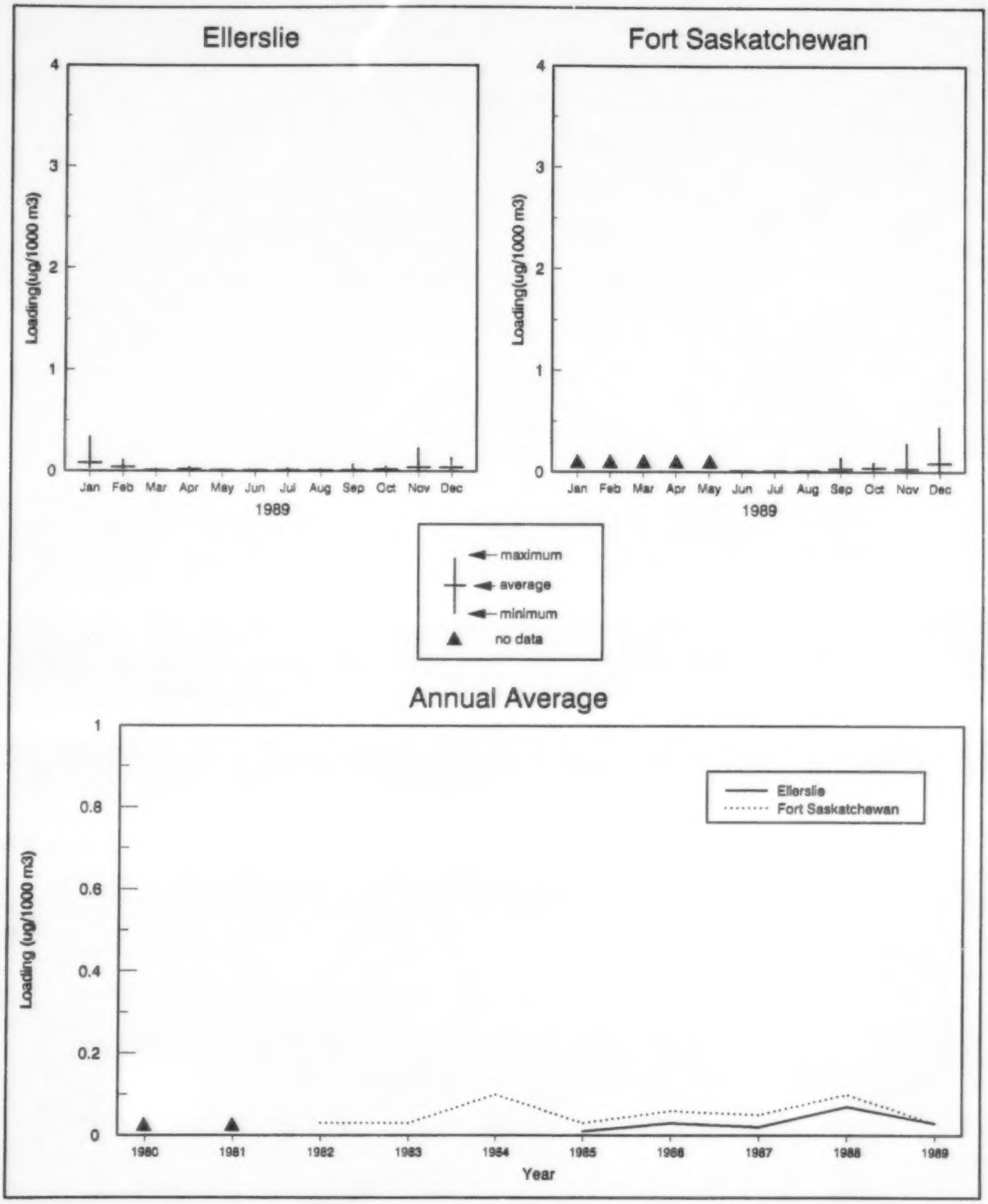

Figure 5-6 Benzo (a) Pyrene loadings at Ellerslie and Fort Saskatchewan.

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5.2.4.1 *Edmonton*

BaP loadings were generally higher at the downtown and residential monitoring stations than at the industrial location. This was due to higher traffic densities in the proximity of the downtown and residential monitoring locations. A maximum BaP loading of 5.0 ug/1000 m^3 was observed in December at the Edmonton residential monitoring station. BaP has shown a significant increase in annual average loadings over the last eight years at the Edmonton residential monitoring location. This increase is likely due to an increase in vehicle traffic in the region.

5.2.4.2 *Calgary*

A peak BaP loading of 3.60 ug/1000 m^3 was recorded during January at the Calgary downtown monitoring location. Relatively high BaP loadings were much more prevalent at the downtown and industrial monitoring locations than at the residential station. Both the downtown and industrial monitoring stations are located close to main traffic arteries. The traffic density is much less in the vicinity of the residential monitoring unit. A slight trend towards higher BaP loadings is evident at the residential monitoring station.

5.2.4.3 *Fort Saskatchewan and Ellerslie*

BaP loadings at Fort Saskatchewan and Ellerslie tend to be lower than those monitored at the Edmonton or Calgary monitoring stations. Maximum 24-hour BaP loadings at Fort Saskatchewan and Ellerslie were 0.45 ug/1000 m^3 and 0.34 ug/1000 m^3, respectively. These values occurred in December and January at Fort Saskatchewan and Ellerslie, respectively.

5.3 LEAD (Pb)

5.3.1 *Characteristics*

Lead in the ambient air exists primarily as particulate matter of inhalable size. Atmospheric lead results predominantly from man-made processes such as the operation of motor vehicles, iron and steel production, solid waste incineration and battery manufacturing. The burning of leaded gasoline by motor vehicles was the largest source of lead in the atmosphere. Lead is emitted from vehicle exhaust in the form of lead vapours, lead alkyls, very fine lead particles and organic halogens such as lead bromide, lead chloride and lead bromochloride. These compounds originate from the lead anti-knock additives used in gasoline.

In Canada, automobile emissions of lead have steadily increased from 2600 tonnes in 1948 to a peak of 14,360 tonnes in 1973. The introduction of unleaded gasoline coupled with restrictions on the lead content in leaded gasoline has resulted in a general decrease in the quantity of lead emitted into the atmosphere.

The next phase in reducing lead levels in leaded gasoline took place on January 1, 1987 when the amount of lead added to gasoline was reduced by one-third. Since September 1987 all new model light-duty vehicles were required to be equipped with catalytic converters which allow only the use of unleaded fuel.

5.3.2 *Method of Monitoring*

Lead is monitored every sixth day at all high-volume monitoring stations according to the NAPS monitoring schedule. High-volume filters undergo laboratory analysis to quantify the amount of lead in the sample.

5.3.3 *Regulations and Guidelines*

Alberta currently regulates lead emissions by licencing each source and limiting their emissions according to the Clean Air (Maximum Levels) Regulation.

5.3.4 *Results*

Lead was monitored at all high-volume monitoring stations in 1989. Lead loadings were substantially greater at monitoring stations located close to major traffic arteries. Annual average lead loadings ranged from 0.04 ug/m^3 at Ellerslie to 0.25 ug/m^3 at the Calgary industrial monitoring station. Seasonal trends in lead loadings were detected, to some extent, at all monitoring stations. Although lead loadings generally drop to a minimum in the summer months, some exceptions to this trend do occur. High winter lead loadings are due to an increased frequency of meteorological conditions that inhibit the dispersion of pollutants, increased idling times by motor vehicles, and decreased vehicle engine efficiency. Figures 5-7 to 5-9 show the mean, maximum and minimum lead loadings by month at each of the monitoring stations.

A trend towards lower lead loadings is indicated at all monitoring stations except at Ellerslie. This is a reflection of a substantial decrease of lead additives in gasoline over the past 10 years.

5.3.4.1 *Edmonton*

Average lead loadings were generally greater at the Edmonton downtown and residential monitoring stations than at the industrial monitoring station. Peak lead loadings at the downtown, residential and industrial monitoring staions were 0.49, 0.72 and 0.24 ug/m^3, respectively. These peak values were measured in the fall and winter seasons. Relatively high lead loadings at the downtown and residential monitoring locations were due to high traffic densities in the vicinity of these two locations.

5.3.4.2 *Calgary*

Lead loadings in Calgary were greater at the downtown and industrial monitoring locations than at the residential monitoring station. Motor vehicle traffic, which is a major source of lead emissions, is greater at the downtown and industrial locations. Maximum lead loadings at the three monitoring stations were 0.54 (downtown), 0.32 (residential) and 0.99 ug/m^3 (industrial). All peak values occurred in October at all three monitoring stations.

5.3.4.3 *Fort Saskatchewan and Ellerslie*

At Fort Saskatchewan and Ellerslie, lead concentrations were consistently lower than at the Edmonton and Calgary monitoring stations. This is likely due to lower densities of vehicular traffic in the area of these two stations. Maximum lead loadings at Fort Saskatchewan and Ellerslie were 0.16 and 0.25 ug/m^3, respectively. These values occurred in December and September, respectively.

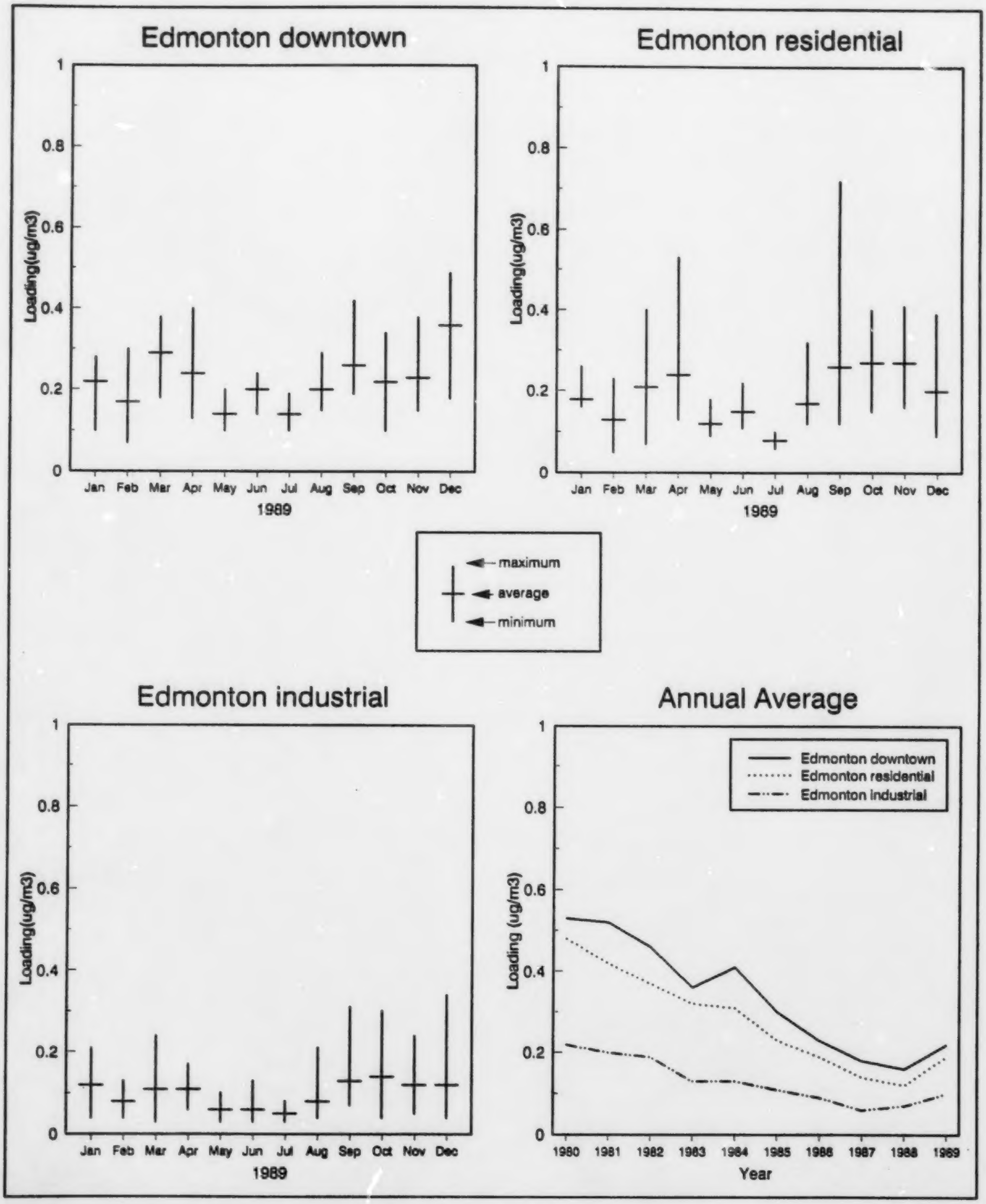

Figure 5-7 Lead loadings at Edmonton.

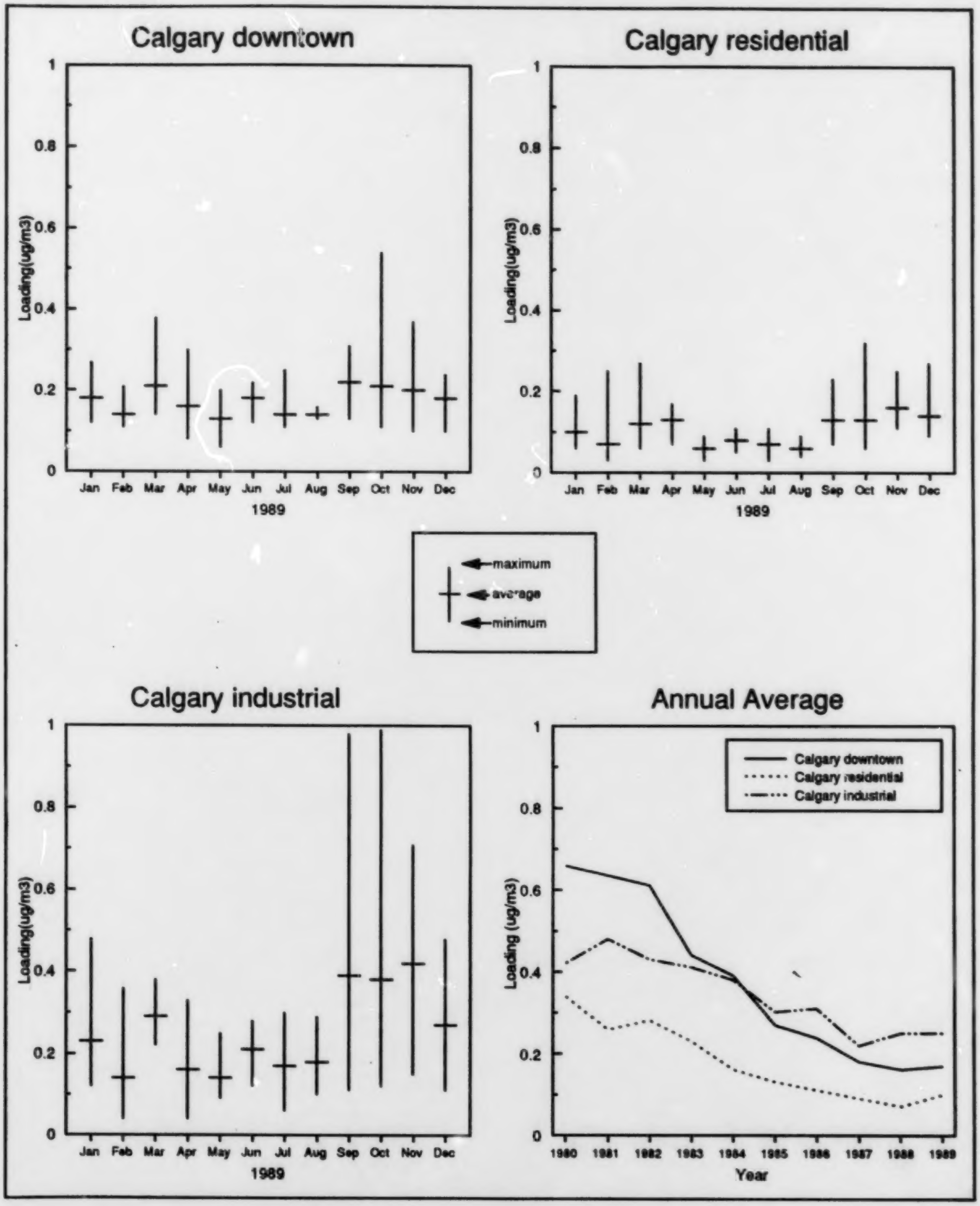

Figure 5-8 Lead loadings at Calgary.

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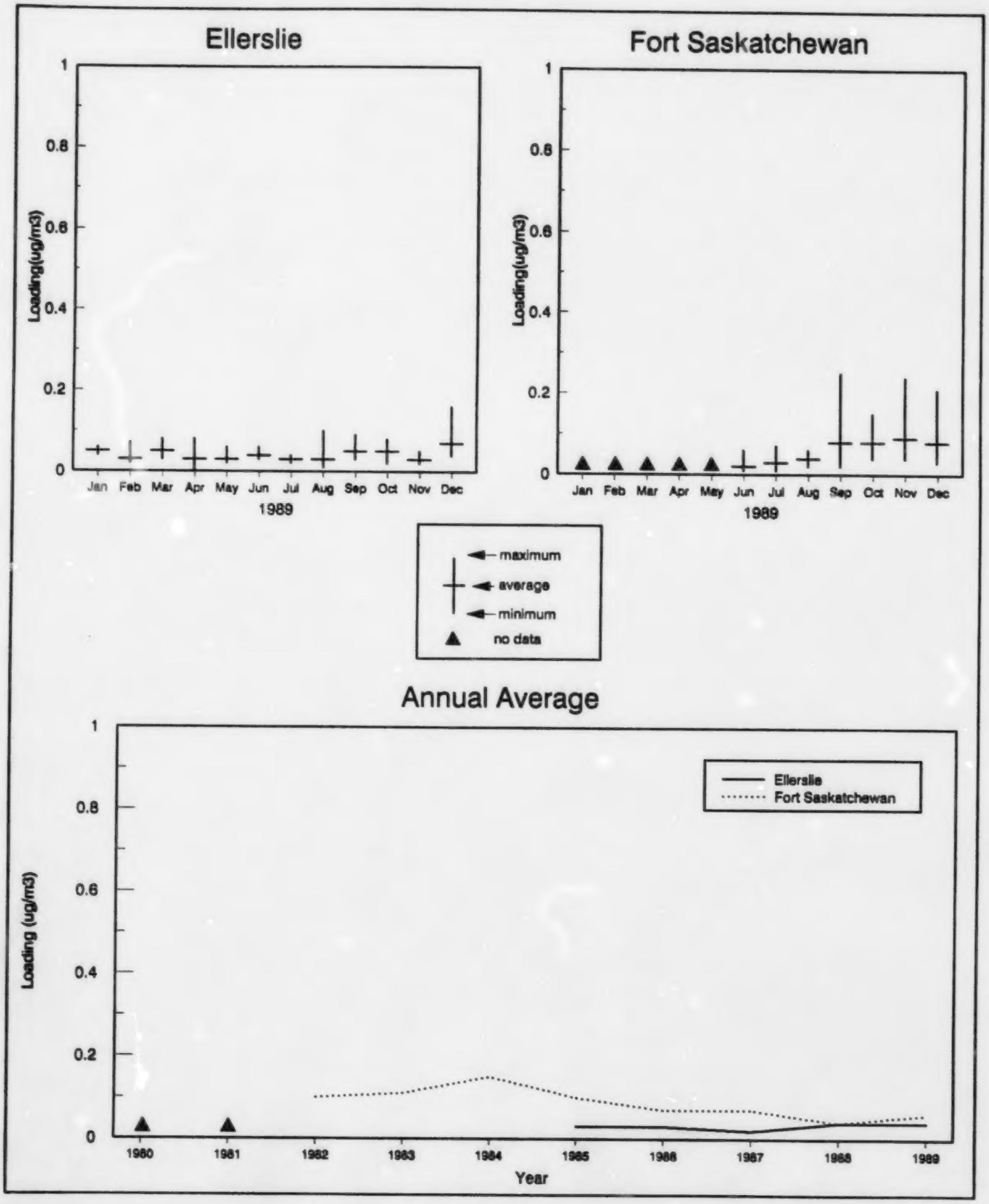


Figure 5-9 Lead loadings at Ellerslie and Fort Saskatchewan.

5.4 VINYL CHLORIDE MONOMER (VCM)

5.4.1 Characteristics

A VCM is a synthetically produced organic molecule that belongs to a group of chemicals known as chlorinated hydrocarbons. This group also includes chloroform, formaldehyde and carbon tetrachloride. Under normal conditions of temperature and pressure, vinyl chloride monomer is a colourless gas with a faint, sweet odour. During industrial use chloride monomer is usually stored under its own vapour pressure as a liquid.

VCM is produced synthetically through several chemical reactions that involve the chlorination of ethylene. The chemical industry uses VCM to produce polyvinyl chloride which is a polymer of VCM. Polyvinyl chloride, a form of plastic, is used in the manufacturing of clothing, building and construction materials, home furnishings, packaging and toys.

Prior to and during the polymerization process, VCM may be released into the environment where it will rapidly break down in the presence of sunlight to form carbon oxides, hydrogen chloride and water.

5.4.2 Method of Monitoring

The VCM monitoring process involves drawing a known volume of air through a glass tube coated, internally, with spherocarb 60/80. Vinyl chloride gas is adsorbed onto the spherocarb and the tube is sent to a laboratory for analysis. A 24-hour accumulated VCM concentration may than be calculated.

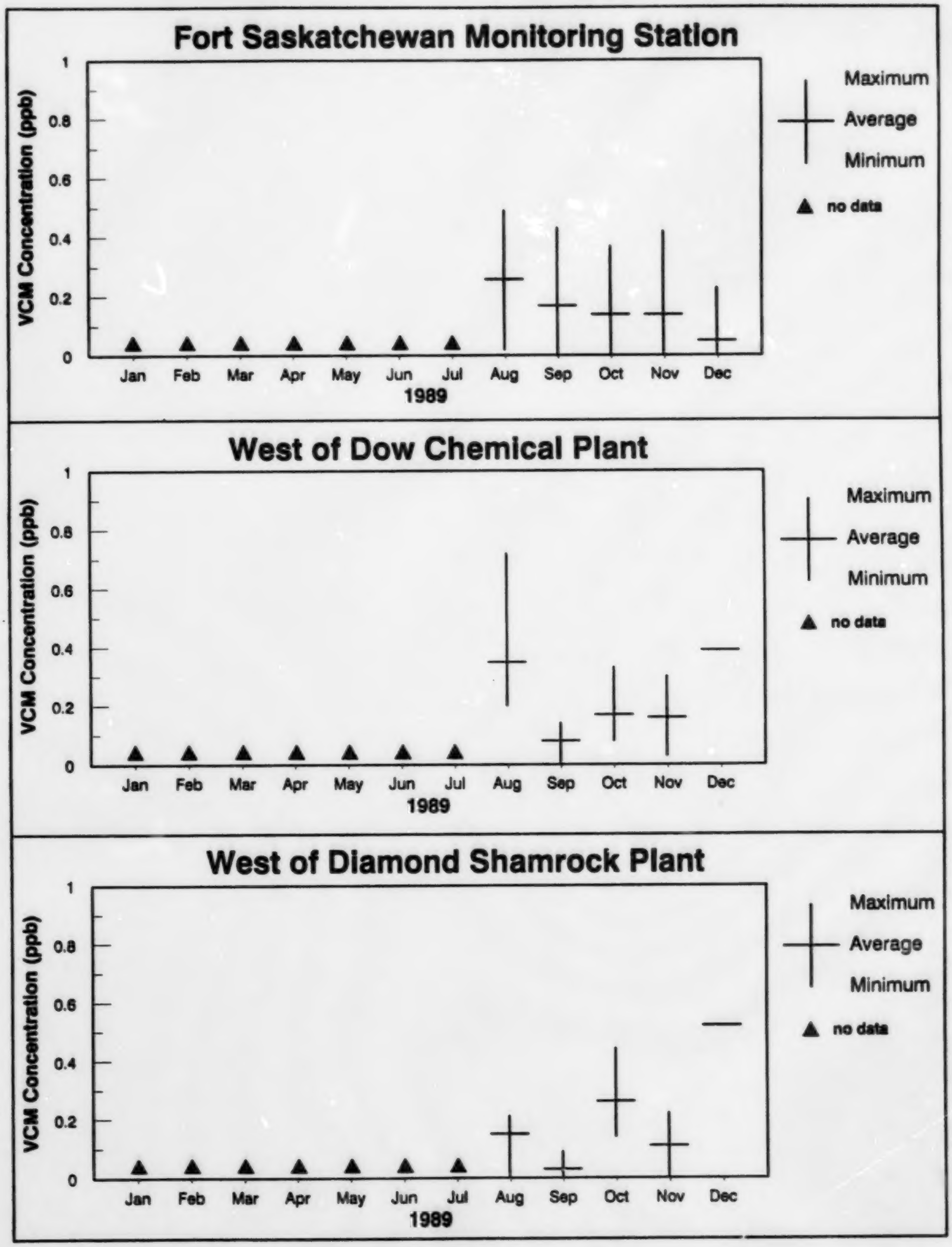
5.4.3 Regulations and Guidelines

Alberta currently regulates VCM emissions by licencing each industrial source and limiting their emissions according to the Clean Air (Maximum Levels) Regulation.

5.4.4 Results

VCM was monitored at three sites in the Fort Saskatchewan region: (1) the Fort Saskatchewan continuous monitoring station; (2) a location west of the Dow Chemical petrochemical processing plant; and (3) west of the Diamond Shamrock chemical processing plant (currently known as the BF Goodrich chemical processing plant). These locations were selected because of their proximity to the petrochemical processing industry. Monitoring at these locations was conducted during the months of August through December. It is important to note that a total of 67 samples were collected at the Fort Saskatchewan continuous monitoring station while only 15 samples are available from the other two monitoring locations. Maximum, average and minimum VCM concentrations are presented by month in Figure 5-10.

Average VCM concentrations for the monitoring period ranged from 0.16 ppb at the Fort Saskatchewan monitoring station to 0.17 ppb at the monitoring location near the Diamond Shamrock plant and 0.23 ppb at the monitoring location near the Dow Chemical plant. Maximum concentrations at these three locations ranged from 0.49 ppb at the Fort Saskatchewan monitoring station to 0.72 ppb at the monitoring station in the vicinity of the Dow Chemical plant. A seasonal tendency in VCM concentrations is not evident from these data.


Fort Saskatchewan Monitoring Station

West of Dow Chemical Plant

West of Diamond Shamrock Plant

Figure 5-10 Vinyl chloride monomer concentrations in the Fort Saskatchewan region.

6. STATIC MONITORING RESULTS

6.1 TOTAL DUSTFALL

6.1.1 Characteristics

Dustfall is described as a measurement of the fraction of particulate matter that does not remain suspended in the atmosphere for an indefinite period of time. Particles collected by dustfall monitors will generally have a larger diameter and mass than those collected as suspended particles (see Section 5.1).

Dustfall may originate from a variety of natural and man-made sources. The most common sources are road dust, wind-blown soil, particles generated through agricultural activities (harvest), large particles emanating from industrial sources and ash from forest and recreational fires.

6.1.2 Method of Monitoring

Total dustfall is collected in a vertically erected cylinder containing water in the summer and iso-propyl alcohol in the winter. Particles settle into the cylinder and onto the surface of the liquid. At the end of the one-month monitoring period, the sample is analyzed to determine the total dustfall loading.

6.1.3 Regulations and Guidelines

The guidelines adopted by Alberta Environment for total dustfall in the ambient air are as follows:

- 53 mg/100 sq cm/30 days (milligrams per 100 square centimeters per 30 days) in residential and recreational areas; and
- 158 mg/100 sq cm/30 days in commercial and industrial areas.

6.1.4 *Results*

Dustfall was monitored at 14 networks, each one consisting of at least one monitoring station, by Alberta Environment in 1989. A total of 79 total dustfall monitoring stations were operated in Alberta during 1989. Figure 6-1 shows the location of total dustfall monitoring networks in Alberta. Table 6.1 summarizes the arithmetic average of total dustfall loadings for each network as well as the frequency of time total dustfall loadings exceeded residential/recreational and industrial/commercial guidelines at each network. Dustfall is collected as a one-month accumulated loading.

Average total dustfall loadings ranged from 36 mg/100 sq cm/30 days at Sherwood Park to 98 mg/100 sq cm/30 days at Coleman and 107 mg/100 sq cm/30 days at Lethbridge. Exceedances of the residential/recreational guideline for total dustfall were observed at all the monitoring networks. The frequency of exceedances ranged from 25% at the Edmonton residential monitoring station to 61% at the Lethbridge monitoring network. Exceedances of the commercial/industrial guideline for total dustfall were observed at many of the static monitoring networks. The percentage of exceedances of this guideline ranged from 0% at Blairmore, Camrose, Edmonton residential, Red Deer (city) and Sherwood Park monitoring networks to 18% at the Lethbridge monitoring network.

6.2 CALCIUM

6.2.1 *Characteristics*

The most common natural sources of calcium are wind-blown soil and road dust. Calcium is emitted as particulate matter from processes used in cement, iron, steel, wood and coal manufacturing. The most common compounds of calcium that occur in particulate matter are limestone and gypsum. (Alberta Environment 1985; Environment Canada 1984).

6.2.2 *Method of Monitoring*

Calcium loadings at certain stations are obtained by laboratory analysis of the dustfall samples. Analysis for calcium is generally performed on total dustfall samples collected from stations located close to facilities which emit calcium into the atmosphere (i.e., cement processing plants).

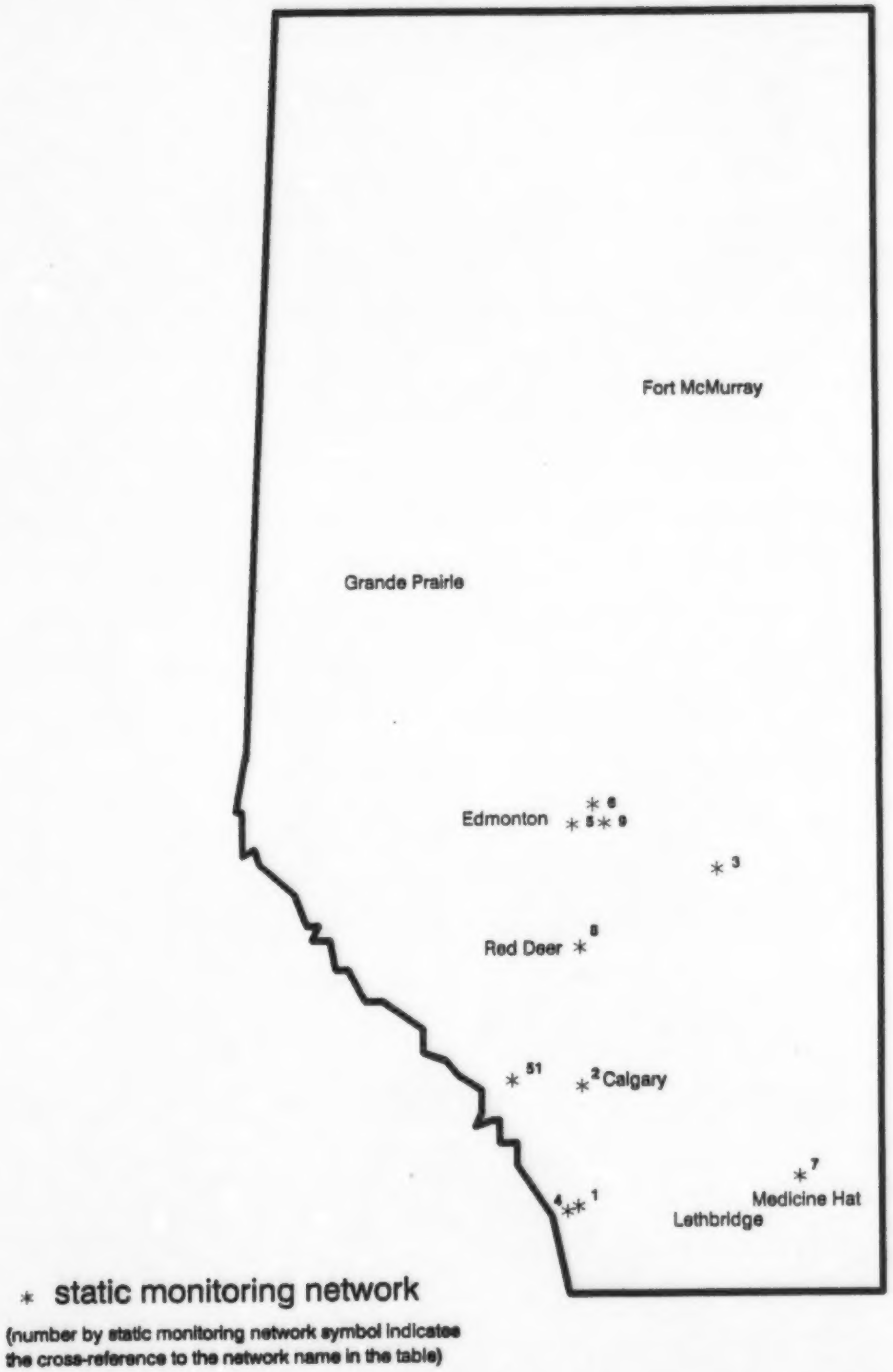

Fort McMurray
Grande Prairie
6
Edmonton
5
9
3
8
Red Deer
51
2 Calgary
7
4
1
Medicine Hat
Lethbridge
* static monitoring network
(number by static monitoring network symbol indicates the cross-reference to the network name in the table)

Figure 6-1 Location of total dustfall monitoring networks.

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Table 6.1 **Averages and exceedances from networks which monitor total dustfall.**

Network Location	# of Stations	Average (mg/100 sq cm/30 days)	Exceedances (percent) a	b	Map Location
Blairmore	2	51	42	0	1
Calgary	6	71	49	7	2
Camrose	1	48	50	0	3
Coleman	12	98	45	15	4
Edmonton	27	71	51	7	5
Edmonton Industrial	1	43	33	8	5
Edmonton Residential	1	38	25	0	5
Exshaw	5	72	50	6	51
Fort Saskatchewan	1	69	42	8	6
Lethbridge	6	107	61	18	48
Medicine Hat	5	47	29	2	7
Red Deer	1	31	**	**	8
Sarcee (Calgary)[c]	8	60	38	10	2
Sherwood Park	3	36	26	0	9

a Refers to exceedances of the residential/recreational guideline (53 mg/ 100 sq cm/30 days).
b Refers to exceedances of the industrial/commercial guideline (158 mg/ 100 sq cm/30 days).
c Special study from July 1984 to December 1989, inclusive.
* ≥ 50 to < 75% of data available.
** Less than 50% of data available.

6.2.3 *Regulations and Guidelines*

There are no regulations or guidelines for atmospheric calcium loadings in Alberta at the present time.

6.2.4 *Results*

Figure 6-2 indicates the locations where calcium was monitored in 1989. Table 6.2 shows the average and maximum calcium loadings for each network. Average calcium loadings ranged form 0.93 mg/100 sq cm/30 days at the Edmonton residential monitoring station to 13.54 mg/100 sq cm/30 days at the Exshaw monitoring network. Maximum values of calcium loadings ranged from 2.51 mg/100 sq cm/30 days at the Edmonton residential monitoring station to 83.67 mg/100 sq cm/30 days at Exshaw. The location of the Exshaw monitoring network relative to limestone deposits and a cement manufacturing plant likely explain the high calcium loadings in the vicinity.

6.3 TOTAL SULPHATION

6.3.1 *Characteristics*

Total sulphation includes all sulphur-containing compounds which are present in the ambient air. These compounds include hydrogen sulphide, sulphur dioxide and mercaptans. Sources of sulphur-containing compounds include emissions from sulphur recovery processes at sour gas plants and as a by-product of gasoline and coal combustion.

6.3.2 *Method of Monitoring*

Total sulphation is measured by a sulphation cylinder or a sulphation plate which has a surface that is impregnated with a reactive lead dioxide. Sulphur compounds react with lead dioxide to produce lead sulphide. The quantity of lead sulphide on the surface indicates the total sulphation loading.

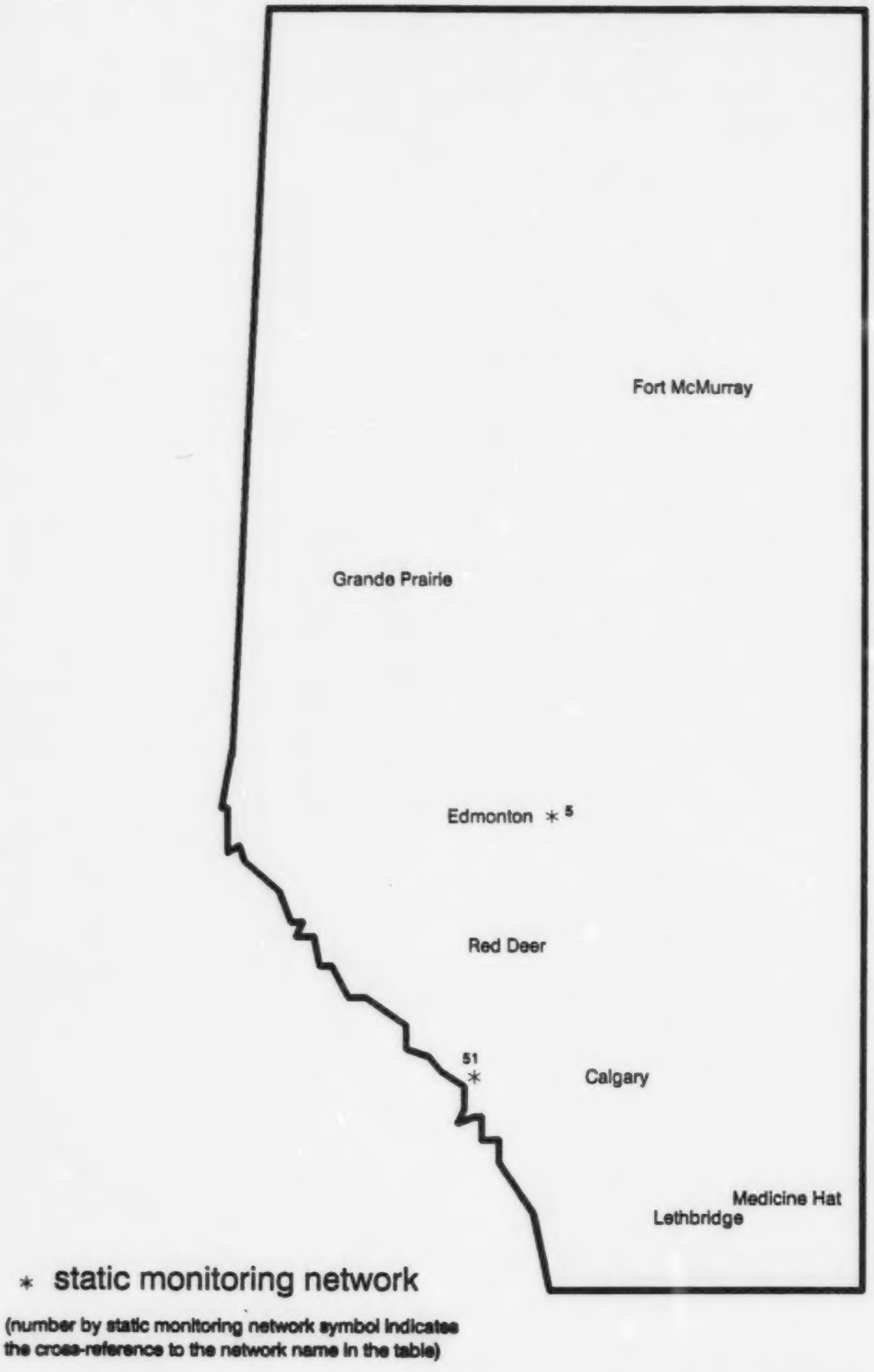
Fort McMurray
Grande Prairie
Edmonton * 5
Red Deer
51 *
Calgary
Medicine Hat
Lethbridge
* static monitoring network
(number by static monitoring network symbol indicates the cross-reference to the network name in the table)

Figure 6-2 Location of calcium monitoring networks.

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Table 6.2 **Averages and maximums from networks which monitor calcium.**

Network Location	# of Stations	Average (mg/100 sq cm/30 days)	Maximum (mg/100 sq cm/30 days	Map Location
Edmonton	3	5.15	14.65	**5**
Edmonton Industrial	1	2.10	10.07	**5**
Edmonton Residential	1	0.93	2.51	**5**
Exshaw	5	13.54	13.54	**51**

6.3.3 *Regulations and Guidelines*

The guideline for total sulphation loading in Alberta is:

- 0.50 mg SO_3 equivalent/day/100 sq cm (milligrams as SO_3 per day per 100 square centimetres).

6.3.4 *Results*

Total sulphation is monitored at 19 networks on a one-month basis, and 34 networks on a three-month basis, throughout the province. The length of the exposure period is dependent on the abundance and type of industrial sources in the area.

6.3.4.1 *One-Month Exposure Period*

A total of 108 static monitoring stations measured total sulphation, on a one-month basis, at 19 networks in Alberta. The location of these networks is indicated in Figure 6-3. The average total sulphation for each network and frequency of exceedances for each network is shown in Table 6.3. There were no exceedances of the regulation for stations which monitor total sulphation on a monthly basis. Average total sulphation values ranged from 0.006 mg/day/100 sq cm at Hinton to 0.081 mg/day/100 sq cm at Redwater.

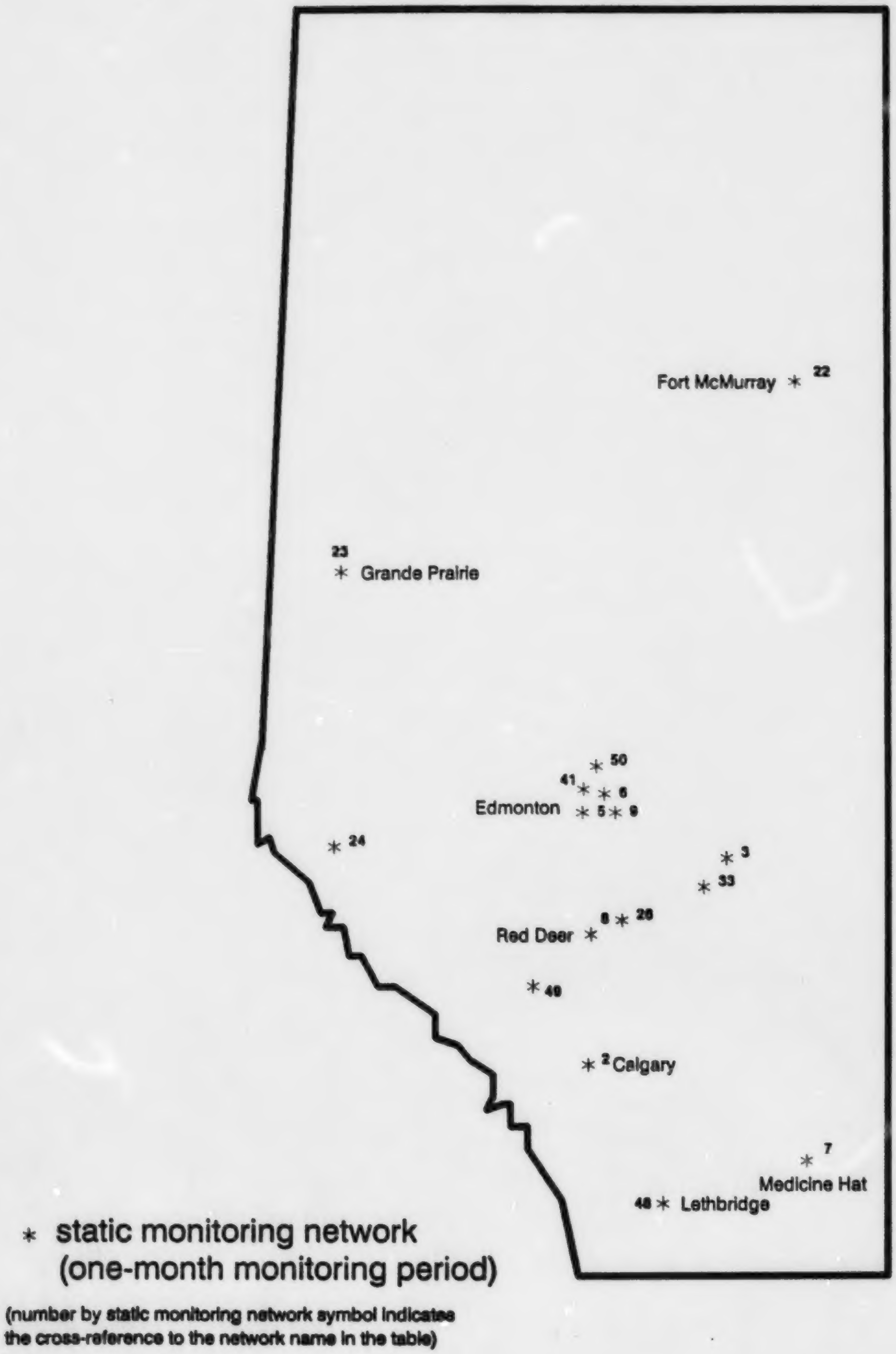
Fort McMurray
22
23
Grande Prairie
24
50
41
6
Edmonton
5
9
3
33
8
28
Red Deer
49
2
Calgary
7
Medicine Hat
48
Lethbridge
* static monitoring network
(one-month monitoring period)
(number by static monitoring network symbol indicates the cross-reference to the network name in the table)

Figure 6-3 Location of total sulphation monitoring networks.

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Table 6.3 **Averages and exceedances from networks which monitor total sulphation on a one-month exposure basis.**

Network Location	# of Stations	Average (mg/day/100 sq cm)	Exceedances (percent)	Map Location
Calgary	38	0.064	0	2
Camrose	1	0.046	0	3
Edmonton	27	0.043	0	5
Edmonton Industrial	1	0.059	0	5
Edmonton Residential	1	0.043	0	5
Fort McMurray	6	0.075*	0*	22
Fort Saskatchewan	4	0.059	0	6
Fort Saskatchewan (special)	1	0.057	0	6
Grande Prairie	1	0.015	0	23
Hinton	3	0.009	0	24
Joffre	2	**	**	26
Lethbridge	5	0.032	0	48
Medicine Hat	5	0.023	0	7
New Norway	1	**	**	33
Raven Brood	1	0.017	0	49
Red Deer (city)	2	**	**	8
Redwater	4	0.081	0	50
Sherwood Park	3	0.057	0	9
St. Albert	2	0.010	0	41

a Refers to exceedances of the guideline (0.50 mg/day/100 sq cm).
* ≥ 50 to < 75% of data available.
** Less than 50% of data available.

6.3.4.2 Three-Month Exposure Period

A total of 140 stations monitor total sulphation, on a three-month basis, in 34 static monitoring networks in Alberta. The location of these networks is presented in Figure 6-4. Table 6.4 shows average total sulphation values for each network and the frequency of exceedances for each network. It is important to note that data from 19 of these networks are not included in this analysis because of insufficient data. Average total sulphation loadings ranged from 0.020 mg/day/100 sq cm at the Edson monitoring network to 0.208 mg/day/100 sq cm at the Redwater monitoring network. Relatively high total sulphation observations in the vicinity of Redwater are likely the result of gas processing activities in the area. There was one exceedance of the regulation for total sulphation at the Redwater network.

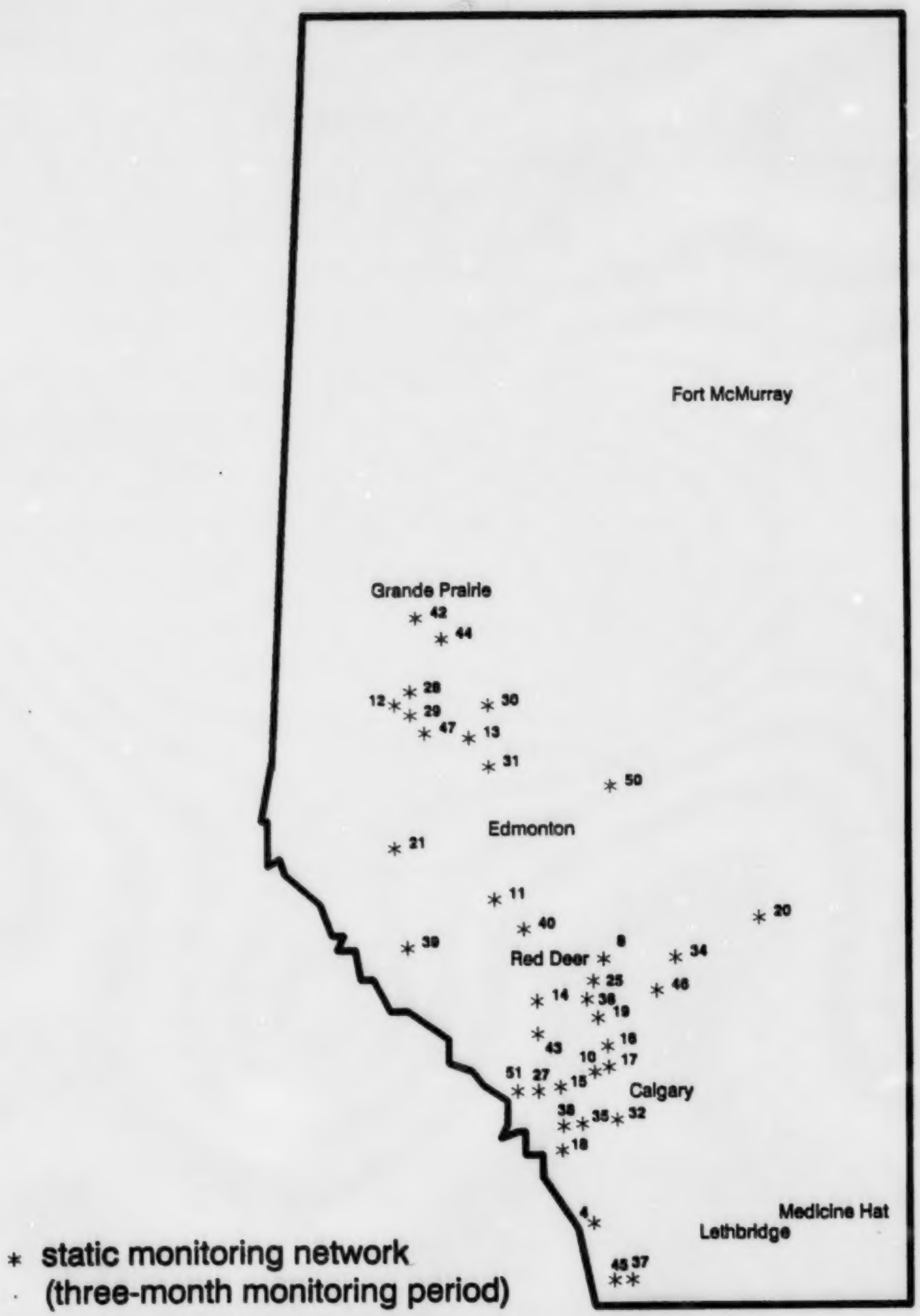
6.4 HYDROGEN SULPHIDE (H_2S)

6.4.1 Characteristics

The characteristics of H_2S are described in Section 4.6 of this report. Industrial sources of H_2S include petroleum refining plants, natural gas plants, petrochemical complexes, coke oven plants, and pulp and paper mills employing the kraft pulping process. H_2S occurs naturally in coal, natural gas, oil, sulphur hot springs, sloughs, swamps and lakes.

6.4.2 Method of Monitoring

H_2S is monitored by an exposure cylinder or an exposure plate which contains a surface which has been impregnated with zinc acetate. H_2S will react with zinc acetate to form zinc sulphide. The quantity of zinc sulphide on the surface is proportional to the quantity of H_2S deposited onto the surface.


Fort McMurray
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42
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8
Red Deer
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43
16
10
17
51
27
15
Calgary
38
35
32
18
4
Medicine Hat
Lethbridge
45
37
* static monitoring network
· (three-month monitoring period)

(number by static monitoring network symbol indicates the cross-reference to the network name in the table)

Figure 6-4 Location of total sulphation monitoring networks.

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Table 6.4 **Averages and exceedances from networks which monitor total sulphation on a three-month exposure basis.**

Network Location	# of Stations	Average (mg/day/100 sq cm)	Exceedances (percent)	Map Location
Balzac	4	0.062	0	10
Bigstone	2	**	**	12
Blue Ridge	4	**	**	13
Buck Lake	4	**	**	11
Caroline	2	**	**	14
Carstairs	4	0.052	0	16
Cochrane	4	0.075	0	15
Coleman	4	0.141	0	4
Crossfield	5	0.061	0	17
Diamond Valley	4	0.043	0	18
Didsbury	8	**	**	19
Edburg	1	**	**	20
Edson	4	0.020	0	21
Innisfail	4	**	**	25
Jumping Pound	4	0.050	0	27
Kaybob	4	**	**	28
Kaybob (south)	4	**	**	29
Lone Pine Creek	5	0.053	0	30
Mayerthorpe	2	**	**	31
Mazeppa	4	0.043	0	32
Nevis	7	**	**	34
Okotoks	5	0.054	0	35
Olds	4	**	**	36
Pincher Creek	6	0.038	0	37
Quirk Creek	6	0.037	0	38
Ram River	5	0.062*	0*	39
Red Deer	4	**	**	8
Redwater	4	0.208	7	50
Rimbey	4	**	**	40
Simonette	2	**	**	42
Sundre	2	**	**	43
Valleyview	2	**	**	44
Waterton	8	0.072	0	45
Wimborne	4	**	**	46
Windfall	4	**	**	47

a Refers to exceedances of the guideline (0.50 mg/day/100 sq cm).
* ≥ 50 to < 75% of data available.
** Less than 50% of data available.

6.4.3 *Regulations and Guidelines*

The guideline for H_2S loading in Alberta is:

- 0.10 mg SO_3 equivalent/day/100 sq cm (milligrams as SO_3 per day per 100 square centimetres).

6.4.4 *Results*

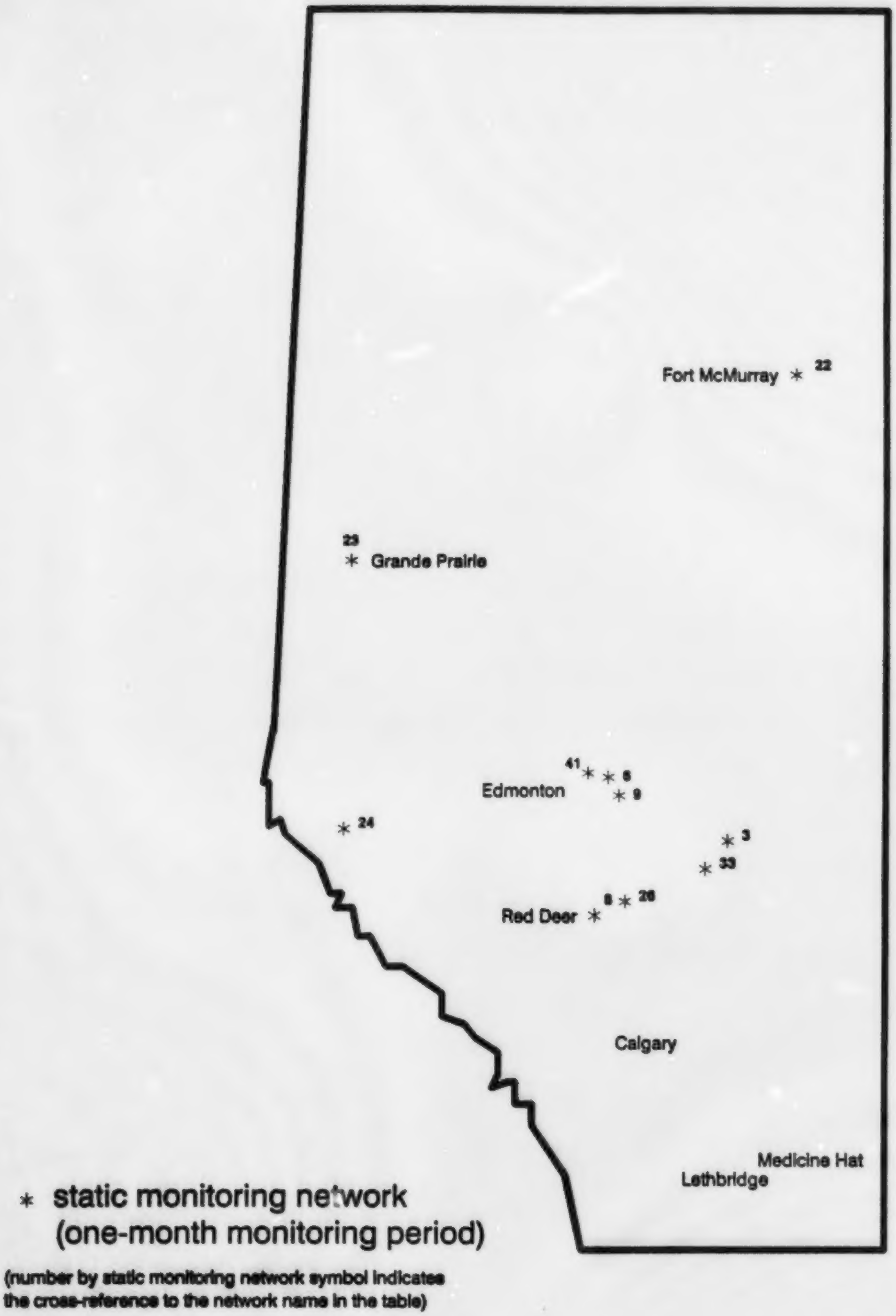
H_2S is monitored on a one-month and three-month basis in the province. A total of 10 networks monitor H_2S on a one-month basis while 34 networks monitor H_2S on a three-month basis.

6.4.4.1 *One-Month Exposure Period*

A total of 22 static monitoring stations measure H_2S on a one-month basis in Alberta. Figure 6-5 shows the location of these networks. Average H_2S loadings and exceedances of the guideline for each network are shown in Table 6.5. Average H_2S loadings ranged from 0.003 mg/day/100 sq cm at Fort Saskatchewan to 0.014 mg/day/100 sq cm at Fort McMurray. No exceedances of the guideline for H_2S were observed in 1989.

6.4.4.2 *Three-Month Exposure Period*

A total of 140 static monitoring stations, in 34 networks, measure H_2S on a three-month basis in Alberta. Due to insufficient data, 19 of these networks are not included in the analysis. Figure 6-6 shows the location of H_2S stations administered by Alberta Environment. Average H_2S loadings for each network and the frequency of exceedances are shown in Table 6.6. Exceedances of the guideline were not recorded at networks which monitor H_2S on a three-month basis. The highest average H_2S loading was observed at Coleman where a value of 0.008 mg/day/100 sq cm was recorded.


Fort McMurray
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Edmonton
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Red Deer
Calgary
Medicine Hat
Lethbridge

∗ static monitoring network
(one-month monitoring period)

(number by static monitoring network symbol indicates the cross-reference to the network name in the table)

Figure 6-5 Location of hydrogen sulphide monitoring networks.

Alberta
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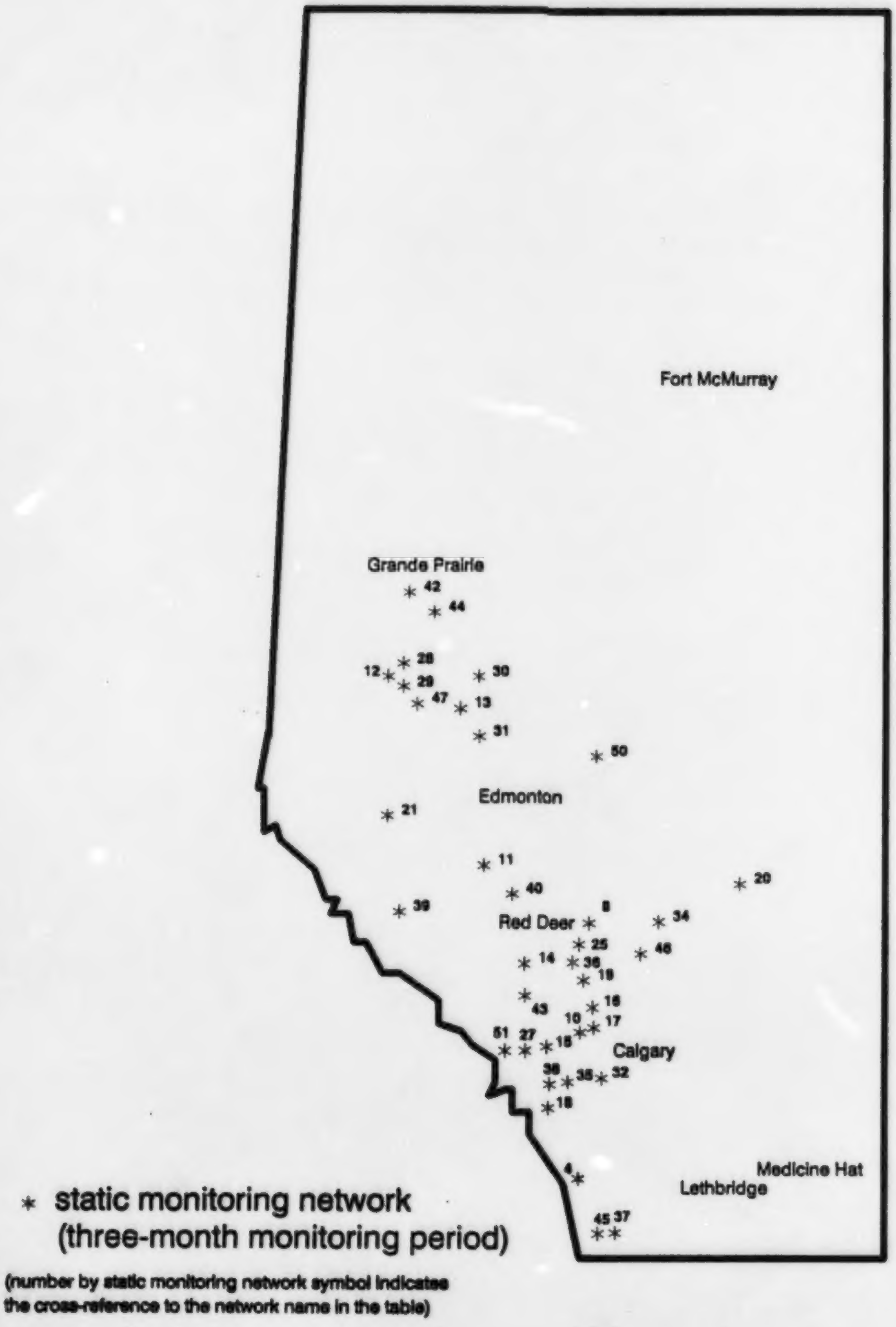
Table 6.5 **Averages and exceedances from networks which monitor hydrogen sulphide on a one-month exposure basis.**

Network Location	# of Stations	Average (mg/day/100 sq cm)	Exceedances (percent)	Map Location
Camrose	1	0.004*	0*	3
Fort Saskatchewan	1	0.003	0	6
Fort McMurray	6	0.014*	0*	22
Grande Prairie	1	0.002	0	23
Hinton	3	0.011	0	24
Joffre	2	**	**	26
New Norway	1	**	**	33
Red Deer (city)	2	**	**	8
Sherwood Park	3	0.007	0	9
St. Albert	2	0.004	0	41

a Refers to exceedances of the guideline (0.10 mg/day/100 sq cm).
* ≥ 50 to < 75% of data available.
** Less than 50% of data available.


Fort McMurray
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15
Calgary
38
35
32
16
4
Medicine Hat
Lethbridge
45
37

* static monitoring network
(three-month monitoring period)

(number by static monitoring network symbol indicates the cross-reference to the network name in the table)

Figure 6-6 Location of hydrogen sulphide monitoring networks.

Alberta
ENVIRONMENT
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Table 6.6 **Averages and exceedances from networks which monitor hydrogen sulphide on a three-month exposure basis.**

Network Location	# of Stations	Average (mg/day/100 sq cm)	Exceedances (percent)	Map Location
Balzac	4	0.002	0	10
Bigstone	2	**	**	12
Blue Ridge	4	**	**	13
Buck Lake	4	**	**	11
Caroline	2	**	**	14
Carstairs	4	0.001	0	16
Cochrane	4	0.004	0	15
Coleman	4	0.008	0	4
Crossfield	5	0.002	0	17
Diamond Valley	4	0.001	0	18
Didsbury	8	**	**	19
Edburg	1	**	**	20
Edson	4	0.002	0	21
Innisfail	4	**	**	25
Jumping Pound	4	0.002	0	27
Kaybob	4	**	**	28
Kaybob (south)	4	**	**	29
Lone Pine Creek	5	0.002	0	30
Mayerthorpe	2	**	**	31
Mazeppa	4	0.002	0	32
Nevis	7	**	**	34
Okotoks	5	0.002	0	35
Olds	4	**	**	36
Pincher Creek	6	0.001	0	37
Quirk Creek	6	0.001	0	38
Ram River	5	0.003*	0	39
Red Deer	4	**	**	8
Redwater	4	0.007	0	50
Rimbey	4	**	**	40
Simonette	2	**	**	42
Sundre	2	**	**	43
Valleyview	2	**	**	44
Waterton	8	0.003	0	45
Wimborne	4	**	**	46
Windfall	4	**	**	47

a Refers to exceedances of the guideline (0.10 mg/day/100 sq cm).
* ≥ 50 to < 75% of data available.
** Less than 50% of data available.

6.5 FLUORIDES

6.5.1 *Characteristics*

Fluorides are discharged into the atmosphere by many industrial operations, the combustion of coal, and the processing of phosphate bearing rock. These industrial processes include: the grinding, drying and calcining of phosphate rock for fertilizer; iron and steel production; kiln firing of ceramic materials for bricks; melting of materials for glassmaking and fluoride-based cleaning; and etching and electroplating agents used in manufacturing.

6.5.2 *Method of Monitoring*

Total fluoride loading is monitored on a monthly basis. Fluorides are collected on a sample plate lined with calcium oxide saturated filter paper. The fluorides settle onto the plate, in particulate form, and are retained by the calcium oxide. The filter paper is then sent to a laboratory for analysis.

6.5.3 *Regulations and Guidelines*

In Alberta, industrial sources of fluorides are required to conduct static monitoring. The guideline for fluoride loading is:

- 40.0 ug water soluble fluorides/100 sq cm /30 days (micrograms of water soluble fluorides per 100 square centimetres per 30 days).

6.5.4 *Results*

Fluorides were monitored by Alberta Environment at Calgary, Fort Saskatchewan, Medicine Hat and Redwater in 1989. These stations are located near industries, such as brick and tile manufacturing, that are industrial sources of fluorides. Figure 6-7 shows the location of these monitoring networks. Table 6.7 indicates the average fluoride loading for each network and the frequency of exceedances for each network.

Average flouride loadings ranged from 4 ug/100 sq cm/30 days at Fort Saskatchewan to 36 ug/100 sq cm/30 days at the Calgary monitoring network. Exceedances of the guideline for fluoride were observed only in the Calgary monitoring network where a total of 20% of fluoride observations exceeded the guideline.

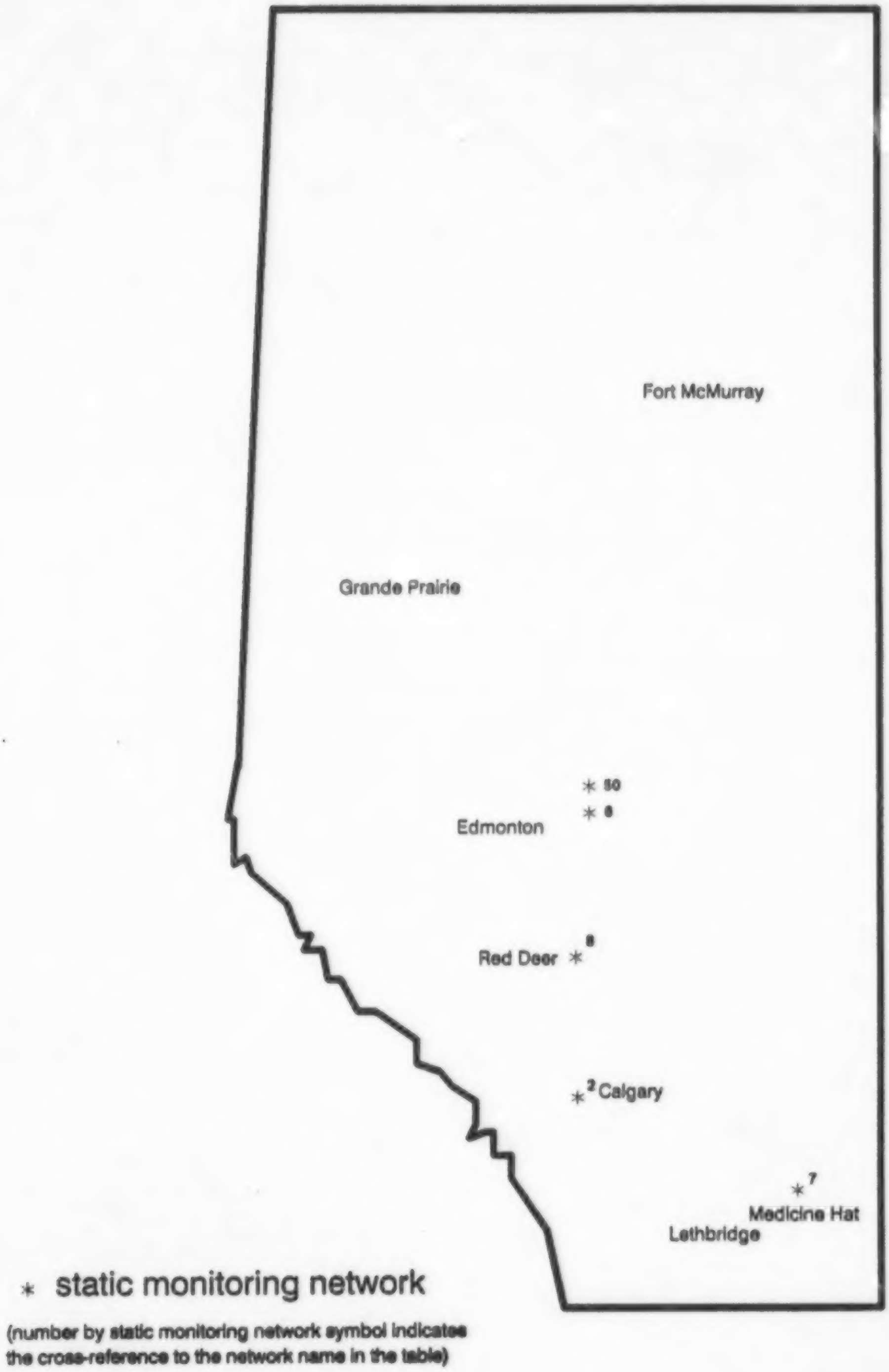
Fort McMurray
Grande Prairie
50
6
Edmonton
8
Red Deer
2 Calgary
7
Medicine Hat
Lethbridge
* static monitoring network
(number by static monitoring network symbol indicates the cross-reference to the network name in the table)

Figure 6-7 Location of fluoride monitoring networks.

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ENVIRONMENT
Environmental Assessment Division
Environmental Quality Monitoring Branch

Table 6.7 **Averages and exceedances from networks which monitor fluorides.**

Network Location	# of Stations	Average (ug/100 sq cm/30 days)	Exceedances (percent)	Map Location
Calgary	3	36	20	**2**
Fort Saskatchewan	1	24	0	**6**
Medicine Hat	1	6*	0*	**7**
Redwater	4	8	0	**50**

a Refers to exceedances of the guideline (40.0 ug/100 sq cm/30 days).
* ≥ 50 to < 75% of data available.
** Less than 50% of data available.

7. ACID PRECIPITATION MONITORING RESULTS

7.1 CHARACTERISTICS

There is an increasing public awareness of the occurrence and effects of acidic substances in the atmosphere. Acidic substances contained in the atmosphere will eventually be deposited on the earth's surface in the form of precipitation (wet deposition) or particulates and gases (dry deposition).

The effects of acid deposition vary depending on the amount of acidic pollutants being deposited and the buffering capacity (ability of soil or water to neutralize the acidity of the precipitation) of the receptor. In the eastern North America and Europe, changes in aquatic life, changes to forest and crop growth, and damage buildings and equipment have been attributed to acid deposition.

Since 1978, precipitation chemistry measurements have been conducted by Alberta Environment. The objectives of the acid precipitation program are to: (1) monitor the quality of precipitation; (2) detect any significant trends in precipitation quality; and (3) determine long-range transport of pollutants into the province.

7.2 METHOD OF MONITORING

Precipitation is collected by a sampler that opens automatically when precipitation (rain or snow) occurs and closes when the precipitation ceases. Each month, the sample is retrieved from the field and sent to the laboratory for analysis. Data obtained as a result of analysis include pH, strong acidity, total acidity, specific conductance, major cations (calcium, ammonium, sodium, magnesium and potassium) and major anions (sulphate, nitrate, chloride and phosphate).

7.3 REGULATIONS AND GUIDELINES

Wet sulphate deposition is often used as an indicator of wet deposition. In eastern Canada, the relationship between hydrogen and sulphate ions is strong enough to establish a basis for wet deposition standards. An objective of 20 kg/ha/yr (kilograms per hectare per year) has been adopted for wet sulphate deposition in eastern Canada.

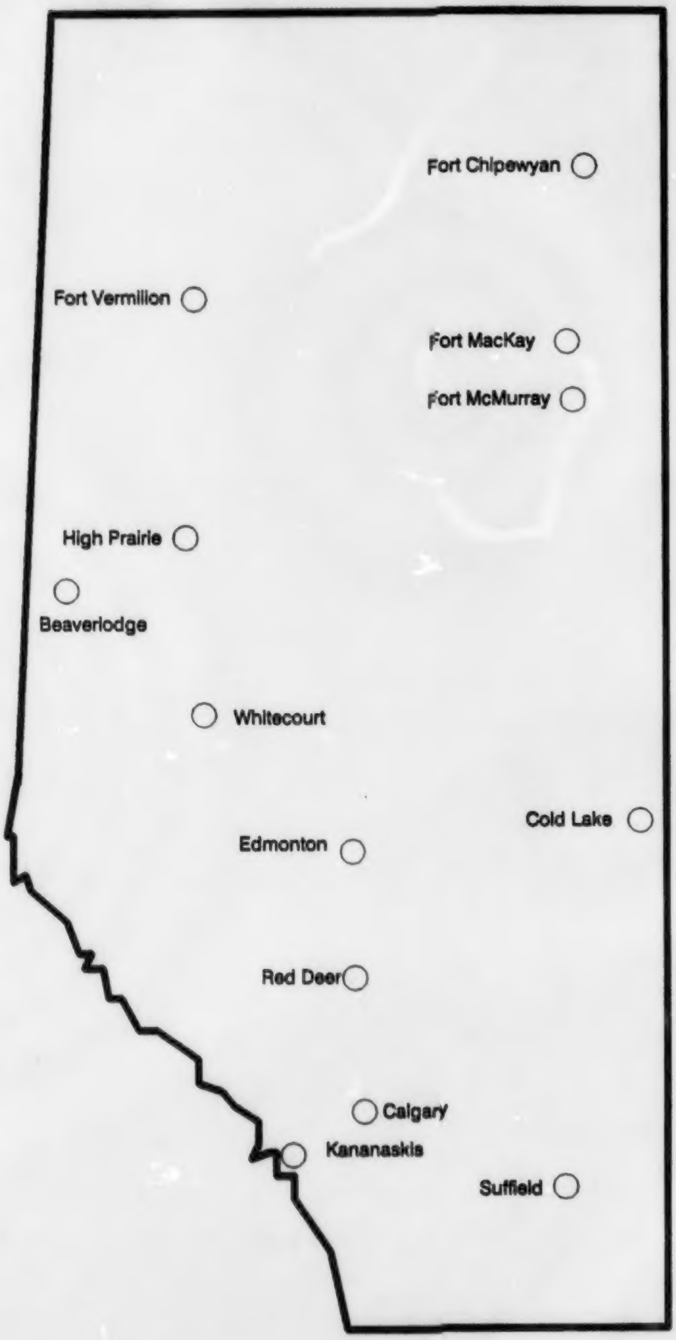
Analysis of acid precipitation data gathered in western Canada has revealed that the hydrogen-sulphate ion relationship is not strong enough to use as a basis for wet deposition standards (Lau 1982; Sandhu and Blower 1986; Bertram et al. 1987; Legge 1988). Other ions such as calcium and magnesium are associated with sulphate ions to form non-acidifying substances such as calcium sulphate and magnesium sulphate. An approach has been developed to take into account the acidifying potential of precipitation after the removal of non-acidifying substances. A range of interim critical loadings has been recommended for western and northern Canada (Interim Acid Deposition Critical Loadings Task Group 1990). This approach is currently being considered by Alberta Environment.

7.4 RESULTS

The location of Alberta Environment precipitation monitoring stations are indicated in Figure 7-1. Table 7.1 shows the volume-weighted average pH of precipitation samples collected at Alberta Environment monitoring stations in 1989. Also indicated in this table are wet deposition rates of anions and cations contained in the precipitation samples. Wet deposition rates are presented in units of kilograms per hectare per year which essentially is the total mass of a specific contaminant deposited onto one hectare during the period of one year by the process of precipitation. At least 75% of data must be available to compute accurate annual wet deposition rates. Wet deposition estimates are not available for Fort Chipewyan, Fort MacKay, Fort McMurray and Whitecourt due to a lack of data.

7.4.1 pH

Uncontaminated precipitation is slightly acidic (pH of 5.6) due to the presence of carbon dioxide. When pollutants such as sulphur dioxide and nitric oxides are emitted into the atmosphere, sulphates and nitrates are formed through oxidation. Sulphates and nitrates combine with water vapour to form sulphuric and nitric acids. The presence of these acids causes precipitation to become more acidic (lower pH).


Fort Chipewyan
Fort Vermilion
Fort MacKay
Fort McMurray
High Prairie
Beaverlodge
Whitecourt
Cold Lake
Edmonton
Red Deer
Calgary
Kananaskis
Suffield

○ acid precipitation monitoring network

Figure 7-1 Location of acid precipitation monitoring stations.

Table 7.1 pH and wet deposition rates for anions and cations at acid precipitation monitoring stations.

Station	pH	Anions (kg/ha/yr)				Cations (kg/ha/yr)				
		$SO_4^{=}$	NO_3^-	Cl^-	$PO_4^{=}$	Ca^{++}	NH_4^+	Na^+	Mg^{++}	K^+
Beaverlodge	5.1	4.3	2.7	0.5	0.1	0.6	0.4	0.3	0.1	0.4
Calgary	5.3	5.7	3.3	0.5	0.1	1.7	1.2	0.3	0.5	0.2
Cold Lake	5.5	5.8	4.5	0.4	0.1	1.1	2.2	0.3	0.3	0.5
Edmonton	5.6	6.4	4.5	0.5	0.2	1.2	2.9	0.2	0.2	0.3
Fort Chipewyan	5.0[a]	a	a	a	a	a	a	a	a	a
Fort MacKay	5.0[b]	b	b	b	b	b	b	b	b	b
Fort McMurray	4.7[a]	a	a	a	a	a	a	a	a	a
Fort Vermilion	5.6	2.0	1.6	0.3	0.2	0.6	1.1	0.2	0.1	0.2
High Prairie	5.5	4.0	2.7	0.5	0.4	1.6	1.7	0.3	0.3	1.2
Kananaskis	5.1	5.2	2.9	0.5	0.1	1.0	0.6	0.4	0.3	0.2
Red Deer	5.5	5.7	3.9	0.3	0.0	1.2	1.8	0.2	0.3	0.2
Suffield	6.0	5.1	5.5	1.0	0.1	2.8	2.3	0.7	0.5	0.5
Whitecourt	5.9[b]	b	b	b	b	b	b	b	b	b

a ≥ 50 to < 75% of data available.
b Less than 50% of data available.

The pH of precipitation samples collected in 1989 by Alberta Environment indicated that the northeastern sector of the province generally had the most acidic precipitation (lowest pH). A pH of 4.7 was recorded as an annual volume weighted average at Fort McMurray. It should be noted that less than 50% of data is available from Fort Chipewyan and Fort MacKay, and between 50 and 75% of data is available at Fort McMurray.

The least acidic (highest pH) precipitation samples were collected at Suffield (pH 6.0) and Whitecourt (pH 5.9). Less than 50% of data is available from the Whitecourt precipitation monitoring station. High Prairie, Cold Lake, Edmonton, Fort Vermilion and

Red Deer all recorded pH values between 5.5 and 5.7, close to that of uncontaminated precipitation.

7.1.2 Anions (sulphate, nitrate, chloride, phosphate)

Anions are negatively charged groups of atoms or molecules formed when chemicals dissociate in water. Sulphuric acid and nitric acid produce sulphate and nitrate ions, respectively, and these are often used as a measure of acidity. Parent chemicals may be emitted into the atmosphere by gas plants, oil sands plants, coal-fired power plants, oil refineries, pulp and paper mills, fertilizer plants and agricultural activities.

Maximum wet sulphate deposition rates were recorded in Edmonton, Cold Lake, Calgary and Red Deer where values of 6.4, 5.8, 5.7 and 5.7 kg/ha/yr were recorded, respectively. These values are well below the eastern Canada objective of 20 kg/ha/yr for wet sulphate. The lowest wet sulphate deposition value was recorded in Fort Vermilion (2.0 kg/ha/yr).

Wet nitrate deposition patterns exibited similar characteristics as that for wet sulphate deposition. Maximum values of wet nitrate deposition were recorded at Suffield (5.5 kg/ha/yr), Edmonton (4.5 kg/ha/yr) and Cold Lake (4.5 kg/ha/yr) while minimum rates were observed at Fort Vermilion (1.6 kg/ha/yr).

Wet chloride deposition rates ranged from 0.3 kg/ha/yr at Fort Vermilion and Red Deer to 1.0 kg/ha/yr at Suffield. Chloride deposition rates at most other stations were in the 0.4 to 0.5 kg/ha/yr range.

Wet phosphate deposition rates were relatively low at all monitoring stations. A maximum phosphate deposition rate of 0.4 kg/ha/yr was recorded at High Prairie.

7.1.3 Cations (calcium, ammonium, sodium, magnesium, potassium)

Cations are positively charge groups of atoms or molecules formed when chemical compounds dissociate in water. All solutions are electronically neutral and, therefore, each anion will be balanced by a cation. Many parent chemicals will emanate from industrial sources such as iron, steel, wood, coal and cement manufacturing. A large percentage of cations will also be contained in wind-blown soil and dust.

Maximum wet calcium deposition was recorded at Suffield, Calgary and High Prairie where values of 2.8, 1.7 and 1.6 kg/ha/yr were recorded. Minimum wet calcium deposition rates were recorded at Beaverlodge (0.6 kg/ha/yr) and Fort Vermilion (0.6 kg/ha/yr).

Maximum ammonium wet deposition rates were observed at Edmonton, Suffield and Cold Lake where rates of 2.9, 2.3 and 2.2 kg/ha/yr were recorded, respectively. A minimum value of 0.4 kg/ha/yr was observed at Beaverlodge.

Maximum wet sodium and magnesium deposition rates were observed at Suffield with values of 0.7 and 0.5 kg/ha/yr, respectively. Wet potassium deposition rates ranged from 0.2 kg/ha/yr at Calgary, Fort Vermilion, Kananaskis and Red Deer to 1.2 kg/ha/yr at High Prairie.

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